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OBSERVATIONS BY ARTIFICIAL SATELLITES AND PROBES

N. P. Yerpylev et al.

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ARTIFICIAL SPACE OBJECTS

(Issue 7)

January 1, 1970 through December 31, 1970.

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CONTENTS

page

FOREWORD 1

Table: Artificial Earth Satellites, Space Probes and Spaceships Launched from January 1 through September 31, 1970 2

A. SOVIET ARTIFICIAL EARTH SATELLITES, SPACE PROBES, AND SPACESHIPS 17

I. Scientific Research Satellites 17

1. Satellites of the "Cosmos" Series 17

II. Meteorological Satellites 29

III. Communications Satellites 30

IV. Space Probes 30

1. Space Probes for the Study of Venus 30

"Venera-7"

2. Space Probes for the Study of the Moon 33

"Luna-16"
"Luna-17"
"Zond-8"

V. "Soyuz" Spaceships

"Soyuz-9" (A. G. Nikolayev and V. I. Sevast'yanov) 42

B. AMERICAN ARTIFICIAL EARTH SATELLITES, SPACE PROBES, AND SPACESHIPS 45

I. Scientific Research Satellites 45

1. Satellites of the "Explorer" Series 45

			Page
	2.	The "OFO-1" Satellites	47
	3.	The "RM" Satellite	49
	4.	Orbital Astronomical Observatory	50
II.	Meteorological Satellites		51
	1.	"ITOS-1" Satellite ("Tiros-M")	52
	2.	"NOAA" Satellite	54
	3.	"Nimbus-4" Satellite	54
III.	Communications Satellites		58
	"Intelsat-3" Satellites		58
IV.	Geodetic Satellites		60
	"TORO-1" Satellite ("Secor")		60
V.	Satellites for Testing of Service Systems		60
	"SERT" Satellite		60
VI.	"Apollo" Spaceships		63
	"Apollo-13" (D. Lovell, F. Haise, D. Swigert)		
VII.	Military Satellites		69
	1.	"Vela" Satellites	69
	2.	Spy Satellites	69

C. ARTIFICIAL SATELLITES OF OTHER COUNTRIES 71

1.	The English Artificial Satellite "Orba"	71
2.	The English Satellite "Skynet-2"	71
3.	The French Artificial Satellite "PEOLE"	72
4.	The Japanese Artificial Satellite "Osumi"	73
5.	The Chinese Artificial Satellite "Chincom-1"	76

	Page
D. INTERNATIONAL SATELLITES	67
1. The "Intercosmos" Satellites	67
"Intercosmos-3" "Intercosmos-4"	
2. The Satellite "ESRO"	78
3. The French-West German Satellite "DIAL"	79
4. The American-Australian "Oscar" Satellites	81
5. "NATO" Communications Satellites	83
APPENDIX	84

FOREWORD

This collection is the seventh in the series "Artificial space objects" (for collections 1-6, cf. the Bulletin of Stations of Optical Observations by Artificial Earth Satellites, No. 45, 1965; No. 47, 1966; No. 52, 1968; No. 58, 1971; No. 59, 1971 and the bulletin Observations by Artificial Heavenly Bodies, No. 61, 1971). It contains a list and description of space objects launched by the Soviet Union, the USA, and other countries in 1970. /4*

In 1970 in all countries 114 successful launches of space objects were made, including 81 in the USSR (83 artificial earth satellites, one piloted spaceship, and 4 space probes were launched into orbit), 29 in the USA (31 artificial earth satellites and one piloted spaceship), two in France (two satellites), and one each in Japan and China. With the help of Soviet space technology two international "Intercosmos" satellites were launched; with American help, 5 international satellites; and with French help, one.

A total of 124 objects went into orbit in 1970 and a large number of parts or components, which will be elaborated later on.

The basic principles for construction of the tables and descriptions have remained as before. Information on the scientific results of the launches was based on preliminary reports and is presented only if it is of special interest. The names of foreign objects in the tables are presented in Latin spelling.

The table and description were composed by V. V. Bazykin with the help of workers of the Section of Observations by Artificial Earth Satellites and the Permanent Exhibit of Works of the USSR Academy of Sciences. The editor of the collection is the senior scientific worker of the Astronomical Council of the USSR Academy of Sciences, Candidate of Physical-Mathematical Sciences G. A. Leykin.

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*Numbers in the margin indicate pagination in the foreign text.

ARTIFICIAL EARTH SATELLITES AND SPACE PROBES LAUNCHED FROM JANUARY 1 THROUGH DECEMBER 31, 1970

pp. Country	Designation adopted	Name of object	Date of launch, length of existence, date of fall or descent (universal time)	Epoch (universal time)	Slope of orbit to equator (degrees)	Period (min.)	Altitude in perigee (km)	Altitude in apogee (km)	page of des.
1	2	3	4	5	6	7	8	9	10
879 USSR	1970 01 A	Cosmos-318	1/70 9 12 1/70 21	1/70 9	65	89.3	204	295	17
	1970 01 B	rocket	cessation of orbiting life August 15, 1970						
880 USA	1970 02 A	spy satellite	1/70 14.78 18 2/70 1	1/70 15.3	109.96	89.69	134	383	43
881 USA	1970 03 A	Intelsat-3F	1/70 15.01 more than 1 million yrs	2/70 16.0	0.9	1,436.1	35,773	35,801	36
	1970 03 B	rocket	20 yrs	1/70 15.7	28.04	629.70	267	35,747	
882 USSR	1970 04 A	Cosmos-319	1/70 15 167 7/70 1	1/70 15	82	102	209	1,537	17
	1970 04 B	rocket	cessation of orbiting life May 2, 1970						

1	2	3	4	5	6	7	8	9	10
883 USSR	1970 05 A	Cosmos-320	1/70 16 25 2/70 10	1/70 1.16	48.5	90	240	342	18
	1970 05 B	rocket	cessation of orbiting life January 28, 1970						
	1970 05 C ' G	5 components	cessation of orbiting life in January-March, 1970						
884 USSR	1970 06 A	Cosmos-321	1/70 20 62 3/70 23	1/70 20	71	92	280	507	17
	1970 06 B	rocket	cessation of orbiting life March 7, 1970						
	1970 06 C ' D	components	cessation of orbiting life in January-February, 1970						
885 USSR	1970 07 A	Cosmos-322	1/70 21 8 1/70 29	1/70 21	65.4	89.7	200	337	17
	1970 07 B	rocket	cessation of orbiting life January 25, 1970						
886 USA	1970 08 A	ITOS-1	1/70 23.48 10,000 yrs	2/70 14.3	102.00	115.10	1,436	1,482	33
	1970 08 B	Oscar-5	10,000 yrs	1/70 25.4	101.95	115.08	1,435	1,481	50
	1970 08 C	rocket	5,000 yrs	1/70 25.4	101.95	115.11	1,441	1,478	
887 USA	1970 09 A	SERT-2	2/70 4.12 800 yrs	2/70 11.8	99.13	105.15	997	1,003	37

1	2	3	4	5	6	7	8	9	10
888 USSR	1970 10 A	Cosmos-323	2/70 10 8 2/70 18	2/70 10	65.4	89.7	206	333	17
	1970 10 B	rocket	cessation of orbiting life February 15, 1970						
889 Japan	1970 11 A	Osumi	2/70 11.18 80 yrs	2/70 14.7	31.07	144.20	339	5,138	45
890 USA	1970 12 A	spy satellite	2/70 11.36 80 yrs	2/70 16.7	98.71	101.39	773	874	43
	1970 12 B	rocket	60 yrs	2/70 18.4	98.74	101.38	772	874	
891 USSR	1970 13 A	Molniya-1	2/70 19 5.5 yrs	2/70 19	65.3	703	487	39,175	20
	1970 13 B , D	components							
892 USSR	1970 14 A	Cosmos-324	2/70 27 85 5/70 23	2/70 27	71	92	283	492	17
	1970 14 B	rocket	cessation of orbiting life April 11, 1970						
893 USSR	1970 15 A	Cosmos-325	3/70 4 8 3/70 12	3/70 4	65.4	89.8	207	348	17
	1970 15 B	rocket	cessation of orbiting life March 10, 1970						

1	2	3	4	5	6	7	8	9	10
894 USA	1970 16 A	spy satellite	3/70 4.93 21 3/70 25	3/70 5.6	88.02	88.76	167	257	43
	1970 16 B	capsule	18 mos	3/70 7.2	88.14	94.16	442	514	
895 France- FRG	1970 17 A	DIAL (WIKA)	3/70 10.51 60 yrs	3/70 10.8	5.44	104.47	436	1,522	49
	1970 17 B	DIAL (MIKA)	30 yrs	3/70 10.8	5.43	104.52	436	1,528	49
896 USSR	1970 18 A	Cosmos-326	3/70 13 7 3/70 20	3/70 13	81.4	90.2	212	393	17
	1970 18 B	rocket	cessation of orbiting life in March, 1970						
897 USSR	1970 19 A	Meteor	3/70 17 50 yrs	3/70 17	81.2	96.4	555	643	19
	1970 19 B	rocket	50 yrs	3/70 18.8	81.17	96.60	518	670	
898 USSR	1970 20 A	Cosmos-327	3/70 18 9 mos	3/70 18	71	95.6	279	855	17
	1970 21 A	rocket	cessation of orbiting life September 27, 1970						
899 USA	1970 21 A	NATO-1	3/70 20.99 more than 1 million yrs	4/70 1.0	2.8	1,401.6	34,429	35,786	51
	1970 21 B	rocket	20 yrs	3/70 21.3	25.67	655.4	295	36,934	

1	2	3	4	5	6	7	8	9	10
900 USSR	1970 22 A	Cosmos-328	3/70 27 18 4/70 9	3/70 27	72.9	89.7	213	340	17
	1970 22 B	rocket	cessation of orbiting life April 1, 1970						
901 USSR	1970 23 A	Cosmos-329	4/70 3 12 4/70 15	4/70 3	81.3	88.8	202	240	17
	1970 23 B	rocket	cessation of orbiting life April 5, 1970						
902 USSR	1970 24 A	Cosmos-330	4/70 7 20 yrs	4/70 7	74.1	95.2	514	548	17
	1970 24 B	rocket	20 yrs	4/70 10.2	74.06	95.12	507	541	
903 USA	1970 25 A	Nimbus-4	4/70 8.35 1,200 yrs	4/70 10.2	99.89	107.29	1,095	1,100	34
	1970 25 B	TORO-1	2,000 yrs	4/70 9.5	99.76	107.09	1,064	1,111	37
	1970 25 C	rocket	1,000 years	4/70 10.2	99.89	106.86	1,066	1,086	
	1970 25 D JY	282 components							
904 USSR	1970 26 A	Cosmos-331	4/70 8 8 4/70 16	4/70 8	65	89.9	213	347	17
	1970 26 B	rocket	cessation of orbiting life April 16, 1970						

1	2	3	4	5	6	7	8	9	10
905 USA	1970 27 A	Vela-11	4/70 8.46 more than 1 million yrs	4/70 9.4	32.41	6,729	111,210	112,160	43
	1970 27 B	Vela-12	more than 1 million yrs	4/70 11.6	32.52	6,745	111,500	112,210	43
	1970 27 C	rocket	more than 1 million yrs	4/70 10.4	32.36	3,005	15,040	110,170	
906 USSR	1970 28 A	Cosmos-332	4/70 11 100 yrs	4/70 11	74.5	100	755	786	17
	1970 28 B	rocket	80 yrs	4/70 12.4	74.05	99.90	744	762	
907 USA	1970 29 A	Apollo-13	4/70 11.80	4/70 11.8 4/70 12.0 4/70 15.2	32.56 33.2 passed 252 km from the far side of the moon	88.07 26,320	186 290	186 572,080	39
	1970 29 B	rocket	fell to the moon April 15, 1970						
	1970 29 C	LEM-7	2.95 4/70 17.75	4/70 12.0	33.2	26,320	200	572,080	39
908 USSR	1970 30 A	Cosmos-337	4/70 15 13 4/70 28	4/70 15	81.4	89.1	217	265	17
	1970 30 B	rocket	cessation of orbiting life April 18, 1970						
	1970 30 C	component	cessation of orbiting life May 2, 1970						

1	2	3	4	5	6	7	8	9	10
909 USA	1970 31 A	spy satellite	4/70 15.66 21 5/70 6	4/70 16.6	110.97	89.70	130	388	43
910 USA	1970 32 A	Intelsat-3G	4/70 23.03 more than 1 million yrs	5/70 17.9	0.21	1,436.2	35,772	35,805	37
	1970 32 B	rocket	20 yrs	4/70 23.7	28.04	643.2	272	36,336	
911 USSR	1970 33 A	Cosmos-334	4/70 23 108 4/70 9	4/70 23	71	92.1	281	508	17
	1970 33 B	rocket	cessation of orbiting life May 16, 1970						
	1970 33 G E	components	cessation of orbiting life in May-June, 1970						
912	1970 34 A	China-1	4/70 24.57 100 yrs	4/70 27.7	68.44	114.09	441	2,386	46
	1970 34 B	rocket	50 yrs	4/70 30.0	68.45	114.09	441	2,386	
	1970 34 C	component							
913 USSR	1970 35 A	Cosmos-335	4/70 24 59 6/70 22	4/70 24	48.7	91	254	415	17
	1970 35 F	rocket	cessation of orbiting life May 17, 1970						

1	2	3	4	5	6	7	8	9	10
914 USSR	1970 36 A	Cosmos-336	4/70 25 10,000 yrs	4/70 25	74	115	1,400	1,500	19
	1970 36 B	Cosmos-337	10,000 yrs	4/70 25	74	115	1,400	1,500	19
	1970 36 C	Cosmos-338	10,000 yrs	4/70 25	74	115	1,400	1,500	19
	1970 36 D	Cosmos-336	9,000 yrs	4/70 25	74	115	1,400	1,500	19
	1970 36 E	Cosmos-340	8,000 yrs	4/70 25	74	115	1,400	1,500	19
	1970 36 F	Cosmos-341	6,000 yrs	4/70 25	74	115	1,400	1,500	19
	1970 36 G	Cosmos-342	5,000 yrs	4/70 25	74	115	1,400	1,500	19
	1970 36 H	Cosmos-343	7,000 yrs	4/70 25	74	115	1,400	1,500	19
	1970 36 I	rocket	2,000 yrs	5/70 3.1	74.04	116.69	1,473	1,590	
915 USSR	1970 37 A	Meteor	4/70 28 60 yrs	4/70 28	81.2	98.1	637	736	19
	1970 37 B	rocket	60 yrs	5/70 4.1	81.24	98.34	571	785	
916 USSR	1970 38 A	Cosmos-344	5/70 12 8 5/70 20	5/70 12	72.9	89.8	206	347	17
	1970 38 B	rocket	cessation of orbiting life May 20, 1970						
917 USSR	1970 39 A	Cosmos-345	5/70 20 8 5/70 28	5/70 20	51.8	89.1	193	276	17
	1970 39 B	rocket	cessation of orbiting life May 23, 1970						

1	2	3	4	5	6	7	8	9	10
918 USA	1970 40 A	spy satellite	5/70 20.90 27.53 6/70 17.43	5/70 22.2	83.00	88.62	162	247	43
	1970 40 B	capsule	2 yrs	5/70 22.4	83.12	94.59	491	503	
919 USSR	1970 41 A	Soyuz-9	6/70 1.79 17.71 6/70 19.50	6/70 1.9	51.7	88.59	207	220	28
	1970 41 B	rocket	cessation of orbiting life June 3, 1970						
920 USSR	1970 42 A	Cosmos-346	6/70 10 7 6/70 17	6/70 10	51.8	89.3	201	289	17
	1970 42 B	rocket	cessation of orbiting life June 13, 1970						
921 USSR	1970 43 A	Cosmos-347	6/70 12 14 mos	6/70 12	48.4	108	223	2,073	17
	1970 43 B	rocket	10 mos	6/70 15.5	48.41	107.77	215	2,039	
922 USSR	1970 44 A	Cosmos-348	6/70 13 42 6/70 25	6/70 13	71	93	212	680	19
	1970 44 B	rocket	cessation of orbiting life June 9, 1970						
	1970 44 C	component	cessation of orbiting life in June, 1970						

1	2	3	4	5	6	7	8	9	10
923 USSR	1970 45 A	Cosmos-349	6/70 17 8 6/70 25	6/70 17	65.4	89.8	203	350	17
	1970 45 B	rocket	cessation of orbiting life June 22, 1970						
924 USA	1970 46 A	spy satellite	6/70 19.48	6/70 20	9.9	1,436	31,680	39,860	43
	1970 46	rocket	3 yrs	9/70 1.4	27.98	579.51	171	33,154	
925 USSR	1970 47 A	Meteor	6/70 23 400 yrs	6/70 23	81.2	102	863	906	19
	1970 47 B	rocket	300 yrs	6/70 27.1	81.23	102.34	810	926	
926 USA	1970 48 A	spy satellite	6/70 25.62 11 7/70 6	6/70 26.9	108.87	89.70	129	389	43
927 USSR	1970 49 A	Molniya-1	6/70 26 5.5 yrs	6/70 26	65	705	470	39,280	20
	1970 49 B	rocket	5.5 yrs	7/70 8.4	65.39	700.30	469	39,021	
	1970 49 C, D	components	cessation of orbiting life in July, 1970						
928 USSR	1970 50 A	Cosmos-350	6/70 26 12 7/70 8	6/70 26	51.8	89.06	204	267	17
	1970 50 B	rocket	cessation of orbiting life June 29, 1970						

1	2	3	4	5	6	7	8	9	10
929 USSR	1970 51 A	Cosmos-351	6/70 27 108 10/70 13	6/70 27	71	92	282	494	17
	1970 51 B	rocket	cessation of orbiting life August 18, 1970						
930 USSR	1970 52 A	Cosmos-352	7/70 7 8 7/70 15	7/70 7	51.8	89.5	205	309	17
	1970 52 B	rocket	cessation of orbiting life July 12, 1970						
981 USSR	1970 53 A	Cosmos-353	7/70 9 12 7/70 21	7/70 9	65.4	89.4	211	309	17
	1970 53 B	rocket	cessation of orbiting life July 16, 1970						
932 USA	1970 54 A	spy satellite	7/70 23.06 26.99 8/70 19.05	7/70 25.2	60.00	90.04	158	398	43
933 USA	1970 55 A	Intelsat-3H	7/70 23.97 more than 1 million yrs	8/70 1	13.3	1,043	19,400	36,030	37
	1970 55 B	rocket	20 yrs	8/70 6.6	27.98	642.7	282	36,294	
934 USSR	1970 56 A	Cosmos-354	7/70 29 0.3 7/70 29	7/70 29	50	87	144	208	17
	1970 56 B, C	rocket and components	cessation of orbiting life July 29, 1970						

1	2	3	4	5	6	7	8	9	10
935 USSR- Socialist countries	1970 57 A	Intercosmos-3	8/70 7 121 12/70 6	8/70 7 10/70 1	49 48.46	99.8 97.3	207 210	1,320 1,068	47
	1970 57 B	rocket	cessation of orbiting life November 17, 1970						
936 USSR	1970 58 A	Cosmos-355	8/70 7 8 8/70 15	8/70 7	65.4	89.7	202	342	17
	1970 58 B	rocket	cessation of orbiting life August 14, 1970						
937 USSR	1970 59 A	Cosmos-356	8/70 10 53 10/70 2	8/70 10	82	92.6	240	600	18
	1970 59 B	rocket	cessation of orbiting life October 1, 1970						
938 USSR	1970 60 A	Venera-7	8/70 17	reached Venus December 15, 1970					20
	1970 60 B, C	rocket and components	cessation of orbiting life August 18, 1970						
939 USA	1970 61 A	spy satellite	8/70 18.62 16 9/70 3	8/70 21.2	110.95	89.67	151	365	43
940 USA- England	1970 62 A	Skynet-2	8/70 19.51 20 yrs	8/70 20.2	28.04	636.5	270	36,041	52
	1970 62 B	rocket	20 yrs	8/70 20.2	28.04	636.5	270	36,041	

1	2	3	4	5	6	7	8	9	10
941 USSR	1970 63 A	Cosmos-357	8/70 19 97 10/70 24	8/70 19	71	92	282	500	18
	1970 63 B	rocket	cessation of orbiting life October 15, 1970						
942 USSR	1970 64 A	Cosmos-358	8/70 20 20 yrs	8/70 20	74	95.2	517	549	18
	1970 64 B	rocket	20 yrs	8/70 24.2	74.03	95.08	505	539	
	1970 64 C	component	cessation of orbiting life in November, 1970						
943 USSR	1970 65 A	Cosmos-359	8/70 22 76 10/70 6	8/70 22	51.5	95.5	210	910	18
	1970 65 B	rocket	cessation of orbiting life August 29, 1970						
	1970 65 C ↑ E	components	cessation of orbiting life in September-October, 1970						
944 USA	1970 66 A	spy satellite	8/70 26.42 4 yrs	8/70 29.3	74.99	94.51	484	504	43
945 USA	1970 67 A	Oscar-19	8/70 27.56 1,300 yrs	8/70 29.2	90.02	107.04	955	1,221	50
	1970 67 B	rocket	700 yrs	9/70 6.9	90.04	107.05	952	1,225	

1	2	3	4	5	6	7	8	9	10
946 USSR	1970 68 A	Cosmos-360	8/70 29 10 9/70 8	8/70 29	65	89.5	209	318	18
	1970 68 B	rocket	cessation of orbiting life September 2, 1970						
	1970 68 C, E	components	cessation of orbiting life in September, 1970						
947 USA	1970 69 A	spy satellite	9/70 1.04 more than 1 million yrs	9/70 15	9.9	1,436	31,680	39,860	43
	1970 69 B	rocket	3 yrs	9/70 15	28.21	588.85	178	33,685	
948 USA	1970 70 A	spy satellite	9/70 3.36 80 yrs	9/79 4.9	98.73	101.30	764	874	43
	1970 70 B	rocket	60 yrs	9/70 9.2	98.75	101.29	765	872	
949 USSR	1970 71 A	Cosmos-361	9/70 8 13 9/70 21	9/70 8	72.9	89.6	207	326	18
	1970 71 B	rocket	cessation of orbiting life September 14, 1970						
	1970 71 C, D	components	cessation of orbiting life in September-October, 1970						

1	2	3	4	5	6	7	8	9	10
950 USSR	1970 72 A	Luna-16	9/70 12.69	Moscow time					
			9/70 20.34	soft landing on moon					
			9/70 21.45	take-off from moon					
			9/70 24.35	return to earth with sample of lunar soil					
	1970 72 B	rocket	cessation of orbiting life September 15, 1970						
	1970 72 C	component	cessation of orbiting life September 15, 1970						
951 USSR	1970 73 A	Cosmos-362	9/70 16 10 mos	9/70 16	71	95.7	281	854	18
	1970 73 B	rocket	6 mos	9/70 17	70.96	95.51	271	815	
952 USSR	1970 74 A	Cosmos-363	9/70 17 12 9/70 29	9/70 17	65	89.6	210	324	18
	1970 74 B	rocket	cessation of orbiting life September 22, 1970						
953 USSR	1970 75 A	Cosmos-364	9/70 22 10 10/70 2	9/70 22	65.4	89.6	211	330	18
	1970 75 B	rocket	cessation of orbiting life September 28, 1970						
	1970 75 C	component	cessation of orbiting life October 9, 1970						
954 USSR	1970 76 A	Cosmos-365	9/70 25 0.06 9/70 25	9/70 25	49.5	87.5	144	210	18
	1970 76 C	rocket	cessation of orbiting life September 25, 1970						
	1970 76 B	component	cessation of orbiting life September 26, 1970						

1	2	3	4	5	6	7	8	9	10
955 USSR	1970 77 A	Molniya-1	9/70 29 5 yrs	9/70 29	65.5	706	480	39,300	20
	1970 77 B	rocket	cessation of orbiting life October 16, 1970						
	1970 77 C	component	cessation of orbiting life October 23, 1970						
956 USSR	1970 78 A	Cosmos-366	10/70 1 12 10/70 13	10/70 1	65	89.5	206	310	18
	1970 78 B	rocket	cessation of orbiting life October 6, 1970						
957 USSR	1970 79 A	Cosmos-367	10/70 3 600 yrs	10/70 3	65.3	104.5	932	1,030	18
	1970 79 B ' E	rocket and components	cessation of orbiting life in October, 1970						
958 USSR	1970 80 A	Cosmos-368	10/70 8 6 10/70 14	10/70 8	65	90.6	212	421	19
	1970 80 B ' E	rocket and components	cessation of orbiting life in October-December, 1970						
959 USSR	1970 81 A	Cosmos-369	10/70 8 4 mos	10/70 8	71	92.3	278	534	18
	1970 81 B	rocket	cessation of orbiting life November 30, 1970						

1	2	3	4	5	6	7	8	9	10
960 USSR	1970 82 A	Cosmos-370	10/70 9 13 10/70 22	10/70 9	65	89.5	208	307	18
	1970 82 B	rocket	cessation of orbiting life October 13, 1970						
	1970 82 C	component	cessation of orbiting life October 27, 1970						
961 USSR	1970 83 A	Cosmos-371	10/70 12 100 yrs	10/70 12	74	99.9	754	780	18
	1970 83 B	rocket	80 yrs	10/70 12.9	74	99.81	743	755	
962 USSR and Socialist countries	1970 84 A	Intercosmos-4	10/70 14 80 yrs	10/70 14	48.5	93.6	263	668	48
	1970 84 B	cessation of orbiting life December 17, 1970							
963 USSR	1970 85 A	Meteor	10/70 15 60 yrs	10/70 15	81.2	97.5	633	674	20
	1970 85 B	rocket	60 yrs	10/70 22.3	81.23	97.62	551	736	
964 USSR	1970 86 A	Cosmos-372	10/70 16 100 yrs	10/70 16	74	100.8	786	828	18
	1970 86 B	rocket	80 yrs	10/70 29.2	74.06	100.7	776	806	
965 USSR	1970 87 A	Cosmos-373	10/70 20 10 yrs	10/70 20	62.9	94.8	490	553	18
	1970 87 B	rocket	cessation of orbiting life in December, 1970						

1	2	3	4	5	6	7	8	9	10
966 USSR	1970 88 A	Zond-8	10/70 20 7 10/70 27	fly-by the moon and return to earth					27
	1970 88 B	rocket	cessation of orbiting life October 26, 1970						
967 USSR	1970 89 A	Cosmos-374	10/70 23 150 yrs	10/70 23	63	112.3	536	2,153	18
	1970 89 B	rocket	100 yrs	10/70 28.5	62.93	111.83	517	2,106	
	1970 89 C V	20 components							
968 USA	1970 90 A	spy satellite	10/70 23.74 19 11/70 11	10/70 24.3	111.06	89.83	135	396	43
969 USSR	1970 91 A	Cosmos-375	10/70 30 150 yrs	10/70 30	63	112.4	538	2,164	18
	1970 91 B	rocket	100 yrs	11/70 3.9	62.78	111.52	526	2,066	
	1970 91 C AC	27 components							
970 USSR	1970 92 A	Cosmos-376	10/70 30 13 11/70 12	10/70 30	65.4	89.5	216	311	18
	1970 92 B	rocket	cessation of orbiting life November 5, 1970						
	1970 92 C	component	cessation of orbiting life November 20, 1970						

1	2	3	4	5	6	7	8	9	10
971 USA	1970 93 A	spy satellite	11/70 6.44 1 million yrs	12/70 1.0	7.8	1,197.1	26,050	35,886	43
	1970 93 B	rocket	20 yrs	11/70 7.1	26.29	635.1	300	35,890	
	1970 93 C	component	cessation of orbiting life November 7, 1970						
972 USA	1970 94 A	OFO-1	11/70 9.25 7 mos	11/70 11.1	37.41	92.64	304	518	30
	1970 94 B	rocket	3 mos	11/70 11.1	37.41	92.71	303	526	
	1970 94 C ↕ E	components							
973 USSR	1970 95 A	Luna-17	11/70 10.74 6.54 11/70 17.28	delivery of Lunokhod-1 to the surface of the moon (Moscow time)					
	1970 95 B, C	rocket and components	cessation of orbiting life November 13, 1970						
974 USSR	1970 96 A	Cosmos-377	11/70 11 12 11/70 23	11/70 11	65	89.4	208	305	18
	1970 96 B	rocket	cessation of orbiting life November 16, 1970						
975 USSR	1970 97 A	Cosmos-378	11/70 17 18 mos	11/70 17	74	105	241	1,763	18
	1970 97 B	rocket	9 mos	11/70 20	74	104.75	233	1,730	

1	2	3	4	5	6	7	8	9	10
976 USA	1970 98 A	spy satellite	11/70 18.89 23 12/70 11	11/70 21	82.99	88.70	185	232	3
	1970 98 B	capsule	2 yrs	11/70 20.6	83.18	94.63	487	511	
977 USSR	1970 99 A	Cosmos-379	11/70 24 2 yrs	11/70 24	51.6	88.7	198	253	18
	1970 99 B	rocket	cessation of orbiting life November 26, 1970						
	1970 99 C, D	components	8 wks						
978 USSR	1970 100 A	Cosmos-380	11/70 24 6 mos	11/70 24	82	102.2	210	1,548	18
	1970 100 B	rocket	4 mos	11/70 25.8	81.96	101.93	197	1,501	
979 USSR	1970 101 A	Molniya-1	11/70 27 5 yrs	11/70 27	65.3	707	435	39,430	20
	1970 101 B	rocket	cessation of orbiting life December 11, 1970						
	1970 101 C	component	cessation of orbiting life December 17, 1970						
980 USSR	1970 102 A	Cosmos-381	12/70 2 1,200 yrs	12/70 2	74	105	985	1,023	19
	1970 102 B	rocket	600 yrs	12/70 4.6	74.03	104.82	967	1,004	
	1970 102 C	component							

1	2	3	4	5	6	7	8	9	10
981 USSR	1970 103 A	Cosmos-382	12/70 2 100 yrs	12/70 2	51.58	144	320	5,040	18
	1970 103 B	rocket	130 yrs	12/70 5.1	51.53	144.07	409	5,045	
	1970 103 C	component							
982 USSR	1970 104 A	Cosmos-383	12/70 3 13 12/70 16	12/70 3	65.4	89.3	208	293	18
	1970 104 B	rocket	cessation of orbiting life December 9, 1970						
983 USSR	1970 105 A	Cosmos-384	12/70 10 12 12/70 22	12/70 10	72.9	89.5	212	314	18
	1970 105 B	rocket	cessation of orbiting life December 15, 1970						
984 USA	1970 106 A	NOAA-1	12/70 11.48 10,000 yrs	12/70 20.9	101.94	114.93	1,429	1,473	34
	1970 106 B	rocket	5,000 yrs	12/70 24.9	101.92	114.91	1,425	1,475	
985 USA	1970 107 A	Explorer-42	12/70 12.45 20 yrs	12/70 12.7	3.04	95.30	522	563	29
	1970 107 B	rocket	8 yrs	12/70 12.4	2.91	95.22	529	549	
986 USSR	1970 108 A	Cosmos-385	12/70 12 1,200 yrs	12/70 12	74	104.8	982	1,005	18
	1970 108 B	rocket	600 yrs	12/70 15.3	74.02	104.64	974	979	

1	2	3	4	5	6	7	8	9	10
987 France	1970 109 A	PEOLE-1	12/70 12.57 70 yrs	12/70 24.7	15.00	98.43	635	749	44
	1970 109 B	rocket	50 yrs	12/70 20.5	15.00	97.00	508	739	
	1970 109 C, D	components							
988 USSR	1970 110 A	Cosmos-386	12/70 15 13 12/70 28	12/70 15	65	89.2	207	275	18
	1970 110 B	rocket	cessation of orbiting life December 19, 1970						
	1970 110 C F	components	cessation of orbiting life in December-January, 1970-1971						
989 USSR	1970 111 A	Cosmos-387	12/70 16 20 yrs	12/70 16	74	95.3	528	560	18
	1970 111 B	rocket	10 yrs	12/70 24	74.01	95.13	513	535	
	1970 111 C E	components							
990 USSR	1970 112 A	Cosmos-388	12/70 18 5 mos	12/70 18	71	92.3	281	532	18
	1970 112 B	rocket	2 mos	12/70 20.4	70.96	92.18	268	494	
991 USSR	1970 113 A	Cosmos-389	12/70 18 60 yrs	12/70 18	81	98.1	655	689	18
	1970 113 B	rocket	60 yrs	12/70 29.7	81.2	98.08	602	729	

1	2	3	4	5	6	7	8	9	10
992 USSR	1970 114 A	Molniya-1	12/70 25 5 yrs	12/70 25	65	712	480	39,600	20
	1970 114 B	rocket	1 mo						
	1970 114 C-F	components	cessation of orbiting life						

A. SOVIET ARTIFICIAL EARTH SATELLITES, SPACE PROBES, AND SPACESHIPS

I. Scientific Research Satellites

1. Satellites of the "Cosmos" Series

From January 1 through December 31, 1970 in the Soviet Union /17
72 satellites of the "Cosmos" series were put into orbit. A list is presented below with an indication of the tabular number and date of launch.

879	"Cosmos-318"	January 9, 1970
882	"Cosmos-319"	January 15, 1970
883	"Cosmos-320"	January 16, 1970
884	"Cosmos-321"	January 20, 1970
885	"Cosmos-322"	January 21, 1970
888	"Cosmos-323"	February 10, 1970
892	"Cosmos-324"	February 27, 1970
893	"Cosmos-325"	March 4, 1970
896	"Cosmos-326"	March 13, 1970
898	"Cosmos-327"	March 18, 1970
900	"Cosmos-328"	March 27, 1970
901	"Cosmos-329"	April 3, 1970
902	"Cosmos-330"	April 7, 1970
904	"Cosmos-331"	April 8, 1970
906	"Cosmos-332"	April 11, 1970
908	"Cosmos-333"	April 15, 1970
911	"Cosmos-334"	April 23, 1970
913	"Cosmos-335"	April 24, 1970
914	"Cosmos-336"	April 25, 1970
"	"Cosmos-337"	"
"	"Cosmos-338"	"
"	"Cosmos-339"	"
"	"Cosmos-340"	"
"	"Cosmos-341"	"

914	"Cosmos-342"	April 25, 1970
"	"Cosmos-343"	"
916	"Cosmos-344"	May 12, 1970
917	"Cosmos-345"	May 20, 1970
920	"Cosmos-346"	June 10, 1970
921	"Cosmos-347"	June 12, 1970
922	"Cosmos-348"	June 13, 1970
923	"Cosmos-349"	June 17, 1970
928	"Cosmos-350"	June 26, 1970
929	"Cosmos-351"	June 27, 1970
930	"Cosmos-352"	July 7, 1970
931	"Cosmos-353"	July 9, 1970
934	"Cosmos-354"	July 29, 1970
936	"Cosmos-355"	August 7, 1970
937	"Cosmos-356"	August 10, 1970 /18
941	"Cosmos-357"	August 19, 1970
942	"Cosmos-358"	August 20, 1970
943	"Cosmos-359"	August 22, 1970
946	"Cosmos-360"	August 29, 1970
949	"Cosmos-361"	September 8, 1970
951	"Cosmos-362"	September 16, 1970
952	"Cosmos-363"	September 17, 1970
953	"Cosmos-364"	September 22, 1970
954	"Cosmos-365"	September 25, 1970
956	"Cosmos-366"	October 1, 1970
957	"Cosmos-367"	October 3, 1970
958	"Cosmos-368"	October 8, 1970
959	"Cosmos-369"	October 8, 1970
960	"Cosmos-370"	October 9, 1970
961	"Cosmos-371"	October 12, 1970
964	"Cosmos-372"	October 16, 1970
965	"Cosmos-373"	October 20, 1970
967	"Cosmos-374"	October 23, 1970
969	"Cosmos-375"	October 30, 1970

970	"Cosmos-376"	October 30, 1970
974	"Cosmos-377"	November 11, 1970
975	"Cosmos-378"	November 17, 1970
977	"Cosmos-379"	November 24, 1970
978	"Cosmos-380"	November 24, 1970
980	"Cosmos-381"	December 2, 1970
981	"Cosmos-382"	December 2, 1970
982	"Cosmos-383"	December 3, 1970
983	"Cosmos-384"	December 10, 1970
986	"Cosmos-385"	December 12, 1970
988	"Cosmos-386"	December 15, 1970
989	"Cosmos-387"	December 16, 1970
990	"Cosmos-388"	December 18, 1970
991	"Cosmos-389"	December 18, 1970

On satellites of the "Cosmos" series scientific apparatus was installed for continuing studies of cosmic space in accordance with the program announced by TASS (cf. Bulletin of stations for optical observation of the earth, 1965, No. 45, p. 58). More detailed information is presented below on several artifical earth satellites of the "Cosmos" series.

"Cosmos-320" (No. 883--January 16, 1970)--as well as the satellite "Cosmos-149" (No. 546), were oriented according to a velocity vector with the help of an aerodynamic system. Solar batteries producing gas and other gaseous elements into the surrounding space were absent. Therefore, these satellites were ideal platforms for installation in their nose cone of manometric and mass-spectrometric apparatus.

The launch of the satellite, in particular, showed that a change in the angle of attack even within the limits of ± 15° causes an error in the measurements of the number of particles passing through a single area of the opening of the instruments in a unit of time on the order of ± 3.5%, which coincided with the error of the experiment.

Thus it was shown that for manometric measurements, the accuracy of orientation achieved with the help of the system of aerodynamic stabilization is completely sufficient.

"Cosmos-336," "Cosmos-337," "Cosmos-338," "Cosmos-339," /19
"Cosmos-340," "Cosmos-341," "Cosmos-342," and "Cosmos-343" were

put into relatively high orbits on April 25, 1970 by one rocket-carrier.

"Cosmos-348" (No. 922--June 13, 1970). The launching of this satellite into orbit was part of a second complex experiment on the study of the upper atmosphere of the earth, polar aurora, and magnetic storms, conducted jointly by scientist-geophysicists from Bulgaria, Hungary, the GDR, Poland, Rumania, the USSR, and Czechoslovakia. The first joint experiment in this field, in accordance with the program of international cooperation of socialist countries, was conducted in the winter of 1968 on the satellite "Cosmos-261" (No. 766). In contrast to the first, the second experiment was conducted in the summertime. Chief attention was devoted to studies of the ionosphere and variations in the magnetic field. At the same time the observations of polar aurora and their effects were made in the Antarctic. Detailed data were obtained on ionospheric probing in a broad network of observatories, studies of the absorption of radio waves were conducted, and seasonal variations in the condition of the ionosphere were studied.

"Cosmos-368" (No. 958--October 8, 1970). On board the satellite scientific apparatus was installed for the testing of experimental systems ensuring the life support of laboratory animals, further study of the influence of factors of space flight on living organisms, and continuation of studies of the physical characteristics of outer space.

Present at the launch of the "Cosmos-368" satellite were General Secretary of the CC of the CPSU L. I. Brezhnev, Chairman of the Presidium of the USSR Supreme Soviet N. V. Podgornyy, Chairman of the Council of Ministers of the U.S.S.R. A. N. Kosygin, and the President of France, G. Pompidou, who was visiting the USSR.

"Cosmos-381" (No. 980--December 2, 1970). The chief experiment was vertical impulse probing of the ionosphere from above to below at 20 fixed frequencies from 2 to 13.4 mHz. The emission of radio signals by the apparatus of the satellite occurred every minute for one second. The reflected signals, carrying information on the concentration of electrons in the ionosphere, were registered and noted down onboard the satellite, and were received over the territory of the USSR without transformation. At the same time with the help of the probes the electron concentration around the satellite was determined. Furthermore, the concentration of electrons through the entire layer of the ionosphere was determined with the aid of the three-frequency Mayak radio station.

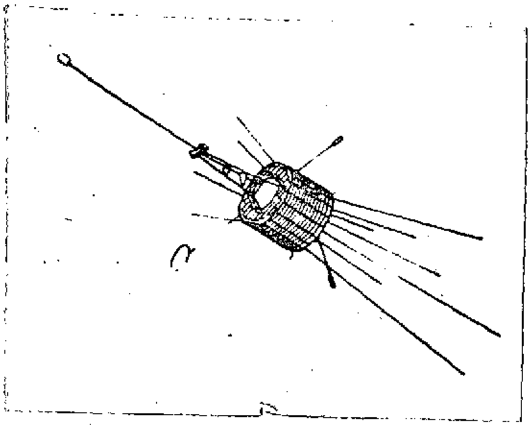

Fig. 1

The ultraviolet emission of the sun in the range from 3 to 1,500 Å was registered. The spectra of low-frequency electromagnetic waves in the ionosphere were studied, the intensity of cosmic rays, the radiological situation in orbit, and the magnetic field of the earth was determined.

The angular position of the satellite relative to the sun was determined by means of radio-technical devices, solar and magnetometric sensors. Inside the satellite the prescribed temperature and pressure were maintained. The electrical supply consisted of solar elements on the lateral surface of the satellite and chemical batteries. For the external appearance of the satellite, see Fig. 1.

II. Meteorological Satellites

In 1970 four "Meteor" meteorological satellites were launched into orbit:

No. 897	"Meteor"	March 17, 1970
No. 915	"Meteor"	April 28, 1970
No. 925	"Meteor"	June 23, 1970
No. 963	"Meteor"	October 15, 1970

/20

The chief purpose of the launches was the receipt of meteorological information necessary for use in the operative weather service. The apparatus of the satellites ensures the reception of images of the cloud cover, the snow cover on the light and dark sides of the earth, and also the reception of data on energy reflected and emitted by the earth and the atmosphere.

Due to the systematic information from onboard the satellites on the condition of the ice cover in the Arctic, it was possible to decrease significantly the number of aerial ice scouting missions. The crew of aircraft before a flight, together with a weather chart, is given a chart of nephelometric analysis and photographs of the cloud cover which is encountered on the way. All ships which sail in the oceans are sent recommended courses, taking into account the hydrometeorological situation. Such recommendations permit a saving of about 5% of running time, which over the course of the last two years has yielded a savings of about 4 million rubles.

Thus, space technology in the USSR is used more and more extensively directly for the needs of the national economy.

III. Communications Satellites

In 1970 launches continued of the communications satellites "Molniya-1," for ensuring the operation of a system of long-distance telephone-telegraph communications, and also for the transmission of programs of the USSR Central Television to points of the "Orbita" network. Five satellites were launched:

No. 891	"Molniya-1"	February 19, 1970
No. 927	"Molniya-1"	June 26, 1970
No. 955	"Molniya-1"	September 29, 1970
No. 979	"Molniya-1"	November 27, 1970
No. 992	"Molniya-1"	December 25, 1970

By the beginning of 1971 new stations of the "Orbita" network began operation in the cities of Okha (Sakhalin Island), Uray, Sovetskaya Gavan', Zeya, Bilibino, and Nebitdag. Together with the first foreign station of "Orbita," which began operation on February 2, 1970 in Ulan-Bator (Mongolian People's Republic), the number of these stations increased to 36 and continues to increase.

Plans for the layout of the "Molniya-1" satellites and the "Orbita" stations may be seen in the previous issues.

IV. Space Probes

1. Space Probes for the Study of Venus

"Venera-7" (No. 938--August 17, 1970). The chief purpose of the launch of the station was to make a landing on the planet Venus, the study of the atmosphere in the process of descent, the taking of measurements down to the surface, and study of the intensity of cosmic rays in the sector of interplanetary flight.

The plan of the station is basically similar to the plan of the "Venera" stations 4, 5, and 6 (cf. No. 580). It weighed 1,180 kg and consisted of an orbital section and a descent apparatus. The orbital section was designed for delivery of the descent apparatus to the planet up to entrance into its atmosphere. Inside the cylindrical sealed body were placed instruments of the radio complex, systems of astroorientation, control, thermal regulation, chemical sources of current and the electronic block of the radiational dosimeter. The descent apparatus was fastened to the upper plate of the orbital section; on the lower plate was the correcting engine installation. On the lateral surfaces were channels of the solar batteries, a pencil-beam antenna, optical instruments, and a system of astral orientation. In flight the station was chiefly in the regime of constant solar orientation and in this case communications with the earth were effected through a semidirectional antenna. At significant distances from the earth and with the necessity of transmitting a large volume of information, a transition was made to a pencil-beam antenna, and at the end of the transmission in this case the station again returned to a regime of flight with constant solar orientation. The descent apparatus was revamped and designed for an external pressure of up to 180 atm and a temperature of up to +530°C. This led to an increase in its weight in comparison with the previous descent apparatus by approximately 100 kg. Its design ensured not only probing and study of the atmosphere of Venus, but also the work of the scientific apparatus located in it on the surface of the planet. For decreasing the overload when touching the surface, a shock-absorbed device was installed. The canopy of the parachute was made of heat-resistant fabric, designed to work at +530°C. So that the apparatus would reach as yet unstudied lower layers of the atmosphere as quickly as possible, the design of the parachute system underwent significant changes. The scientific apparatus allowed the measurement of temperature in a range of from +25 to +540°C and a pressure of from 0.5 to 150 atm.

The launch was made at 8 h, 38 m Moscow time on August 17, 1970. On the route of the flight on October 2 and November 17, corrections of the trajectory were made, ensuring descent onto the planet and arrival of the station during radio contact from ground measuring points. The distance was measured with an accuracy of 1 km, and the radial speed of the station relative to the earth, with an accuracy of 2 cm/sec.

After a 120-day flight, at 7 h, 58 m, 38 sec, on December 15 upon entrance into the atmosphere of Venus the descent apparatus was separated from the station, under the action of aerodynamic forces developed into a nose cone up front, and was held in this position by a damper device. Its velocity, due to aerodynamic braking, decreased relative to the planet from second cosmic (about 11.5 km/sec) to 200 m/sec. The overloads reached 350 units, and the temperature behind the shock wave was 11,000°C. The parachute was put into operation automatically with an external pressure of about 0.7 atm at an altitude of about 60 km.

At 8 h, 34 m, 10 sec, on December 15 the descent apparatus made a landing onto the surface of Venus. The distance between the earth and Venus on this day was 60.6 million km. The speed of descent of the apparatus and the size of the path traveled by it in the atmosphere were determined according to the Doppler shift of the frequency of the highly stable generators with which the apparatus was equipped. At the end of the descent section it was established according to frequency changes that the speed of descent had become zero, while the shift in frequency corresponded to the speed of movement relative to the earth of the section of the surface of Venus on which, according to calculations, the apparatus landed. After the landing, signals were received for 23 min longer, but the magnitude of the signal decreased 100 times, apparently as a result of the deviation of the axis of the antenna from the direction toward the earth. During the descent the flight commutator remained in one position on the surface of the planet; therefore information was transmitted only on the temperature of the environment. The temperature increased during descent, and after landing it did not change. The law of change in temperature turned out to be close to adiabatic. On the basis of the measurements made and the data from previous stations, the distribution of pressure and density in the entire layer of the atmosphere was calculated. It turned out that in the landing spot the temperature was 475 ± 20°C, and the pressure was 90 ± 15 atm. The density of the atmosphere at the surface is approximately 60 times greater than the density of the atmosphere at the surface of the earth. Scientific information was transmitted for the first time directly from the surface of another planet.

The intensity of cosmic rays was measured in the course of the flight of the station with the aid of a radiational dosimeter in the orbital section. It is especially important that data were received on the intensity of cosmic rays according to one-time measurements by the apparatus of satellites, ground devices, instruments of "Lunokhod-1" and "Venera-7" at various distances from the earth. An observation was made of the effects of the powerful chromospheric flare on December 10, 1970. Banners with the image of V. I. Lenin and State Coat of Arms of the Soviet Union were delivered to the surface of Venus.

2. Space Probes for Studying the Moon

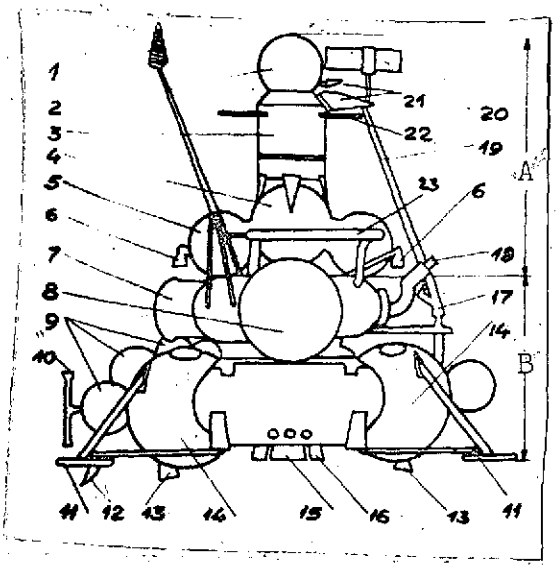

Fig. 2

"Luna-16" (No. 950--September 12, 1970)--an automated station, for the first time permitted the solution of new problems: the collection of samples of lunar soil and their transmittal to the earth. /22

The station consisted of a landing stage with a soil-gathering device and the Luna-zemlya rocket with a return apparatus. The weight ("earth") on landing on the moon was 1,880 kg (Fig. 2).

Explanations for the illustration: 1 - antenna, 2 - return apparatus, 3 - instrument section of the Luna-zemlya rocket, 4 - central fuel tank of the rocket (with oxidizer), 5 - side tank of the rocket (with fuel), 6 - control nozzles, 7 - torr instrument compartment of the landing stage, 8 - cover of the instrument section, 9 - balloons with fuel for the engines of the system of orientation and stabilization and with gas for expulsion of fuel from the tanks, 10 - engines of the system of orientation and stabilization, 11 - supports for the landing device, 12 - mirror of the radioaltimeter, 13 - engines of stabilization, 14 - fuel tank, 15 - engine of the Luna-zemlya rocket, 16 - engines with small thrust, 17 - drive for moving the arms of the soil-gathering device, 18 - telephotometers, 19 - arm of the drilling mechanism, 20 - drilling mechanism (soil-collecting device), 21 - mechanism for sealing the return apparatus, 22 - receiving and transmitting antennas, 23 - radiator of the system of thermal regulation. A - Luna-zemlya rocket, B - landing stage.

The landing stage is an autonomous rocket unit. Its chief engine with regulated thrust ensured the correction of the trajectory, braking in transition to selenocentric orbit, maneuvers in this orbit, descent from circumlunar orbit, and soft landing on the moon. In the completion section two independent engines with small thrust operated. The fuel was stored in spherical tanks, structurally united by cylindrical instrument sections, containing systems for control, stabilization, orientation, thermal regulation, radio system, a programmed-time device, sources of electrical energy, etc. On the landing stage were installed shockabsorber supports for landing on the moon and a soil-collecting device consisting of a drilling machine, arms, and drives for moving it relative to three axes. On the exterior surfaces of the section were fastened tanks with reserve fuel, which were separated before landing on the moon (not shown in the illustration). The landing section serves as a starting device for the Luna-zemlya rocket when it starts from the moon.

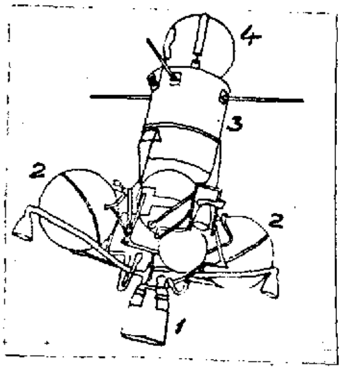

Fig. 3

The Luna-zemlya rocket (Fig. 3) consisted of a liquid-fuel engine (1), fuel tanks (2), and an instrument section (3), with a spherical return apparatus (4) fastened on it. One of its three sections was a container which closed hermetically after samples of lunar soil were placed in it.

The "Luna-16" station was launched at 16 h, 26 m Moscow time on September 12, 1970. The station was launched in an artificial earth satellite orbit with an altitude in apogee of 212.2 km, at an inclination toward the equator of 51°36'. Twenty minutes after the start, on the signal of the flight programmed-time device, the engine of the last stage of the rocket carrier was switched on and the station went out onto the route of flight toward the moon. On September 13 a correction of the trajectory was made. The engine of the /23
station worked for 6.4 sec. A second correction was not required. On September 17 at 2 h, 38 m the engine was switched on in the prescribed region of circumlunar space and the station transferred to a selenocentric orbit with the following parameters: altitude above the surface of the moon, 110 km; inclination toward the lunar equator, 70°; period of revolution, 1 h, 59 m. In the last three days a prelanding orbit was formed. In the course of maneuvers, the angle of inclination toward the equator was changed, and an altitude of periselenion of 15 km and of aposelenion of 106 km were achieved.

On September 20 at 6 h, 06 m preparation for landing began. Moreover, from 6 h, 41 m to 7 h, 21 m the station was on the far side of the moon and communications were not maintained with it. At 8 h 12 m, by switching on the braking engine, the station was transferred to the regime of descent. At the prescribed altitude and upon attaining the calculated vertical velocity (which were determined by a flight Doppler measuring device of velocity and an altimeter) the braking engine was again switched on, lowering the speed of the station at an altitude of 20 m to 2.5 m/sec.

At this altitude the chief engine was switched off and two engines with small thrust were switched on on command of a gamma-altimeter (at an altitude of about 2 m).

On September 20 at 8 h, 18 m the station made a soft landing in the region of the Sea of Fertility at a point with the coordinates: 0°41' south latitude, 56°18' east longitude. The actual deviation from the center of the chosen area was about 1.5 m.

On the surface of the moon, on command from the earth, the soil-collecting device was put into action, ensuring contact of the electrical borer with the surface layer (controlled with the aid of telephotometer chambers), drilling to a depth of 35 cm, collection of soil and its placement in the container of the return apparatus, which was automatically hermetically closed. Besides the taking of lunar soils, measurements were made of the temperature of elements of the structure of the station and of the level of radiation on the lunar surface.

On September 21 at 4 h, 50 m, at a distance of about 5,000 km from the earth the return apparatus was separated from the instrument section. At 8 h, 10 m it entered the dense layers of the atmosphere. Its speed here was second cosmic (it exceeded 11 km/sec), the maximal overloads reached 350 units, and the temperature of the border layer was more than 11,000°C. After passing through maximum temperatures and overloads, a signal was given for shooting out the roof of the parachute hatch. The braking parachute opened at a descent speed of 300 m/sec at an altitude of 14.5 km. At an altitude of around 11 km the braking parachute was separated and the main parachute opened. At the same time the bearing transmitters were switched on, the signals of which were received at 8 h, 14 m by aircraft and helicopters of the search complex. At 8 h, 26 m, 69 h and 43 m after start from the moon, the return apparatus made a landing 80 km southeast of the city of Dzhezkazgan. In 3 min a helicopter landed near it, and in 17 min, an operative-technical group.

The lunar soil was sent to a special laboratory of the USSR Academy of Sciences and installed in a receiving chamber filled with extremely pure helium. The soil consists of small-grained matter with small particles of rocks and minerals, and the number of relatively large grains increases with an increase in depth. The color of the soil is dark gray. It changes depending on the direction of the light relative to the observation The greater amount of the rock particles belong to various types of basalts. The total weight of a sample of regolith is somewhat more than 100 g. The average dimension of the grains is 0.08-0.1 mm. From a depth of 15 cm and more, particles measuring more than 3 mm are encountered. The average volume weight in the natural state at a depth of drilling of the drill of 1.2 g/cm^3 after spillage is 1.8 g/cm^3. Comparison with the composition of samples delivered by the crew of Apollo-12 (No. 867) testifies to the fact that crystal rocks of the surface of the lunar seas belong to one basalt type, but differ somewhat in the content of individual chemical elements. It may be supposed that the general /24 course of differentiation of matter of the earth and the moon traveled similar paths.

The samples of lunar soil delivered with the help of the "Luna-16" station were subjected to varied study in scientific research institutions of the USSR, and were also transmitted for study to scientists of other countries, in particular to France and the USA; were exhibited in the "Space" Pavilion of the USSR Academy of Sciences; and were shown at foreign exhibitions.

The successfully conducted flight of the "Luna-16" station created a basis for still wider use of unmanned stations in the study of space, which allows, at relatively small expense (in comparison with flights of piloted stations), the execution of a broad complex of studies.

"Luna-17" (No. 975--November 10, 1970) was launched at 17 h 44 m on November 1970 with the purpose of testing the new flight systems of the station and of the further study of the moon in the region near the landing site, and also the study of circumlunar space.

In the course of the flight to the moon, 36 communications broadcasts were made with the station. On November 12 and 14 corrections of the trajectory were made. As a result of braking on September 14 the station transferred to selenocentric orbit with the following parameters: altitude over the surface of the moon, 85 km; inclination to the surface of the lunar equator, 141°; period of rotation, 1 h, 56 m. After maneuvering many times, on November 17 at 6 h, 47 m the station made a soft landing on the moon in the region of the Sea of Rains south of the Gulf of Raduga in a point with coordinates of 38°17' north latitude and 35°88' west longitude. The operation of descent from selenocentric orbit and the soft landing on the moon were executed with the aid of a unified stage, similar to the landing stage of the "Luna-16" station (No. 950).

On the landing stage of the station a self-propelling apparatus, the "Lunokhod-1," was installed--the first movable automated laboratory in cosmonautics designed for complex study of the features of the structure of the lunar surface, of the circumlunar environment and of distant space objects and permitting the study not only of the landing spot on the moon, but also an extensive region of the moon adjacent to it. After the landing of the station, checking on the functioning of its flight systems, and examination of the lunar surface, on command from earth at 9 h, 28 m on November 17 the "Lunokhod-1" went off from the "Luna-17" station on a special ramp, traveled a distance of 20 m from the landing stage, and started to execute the planned experiments.

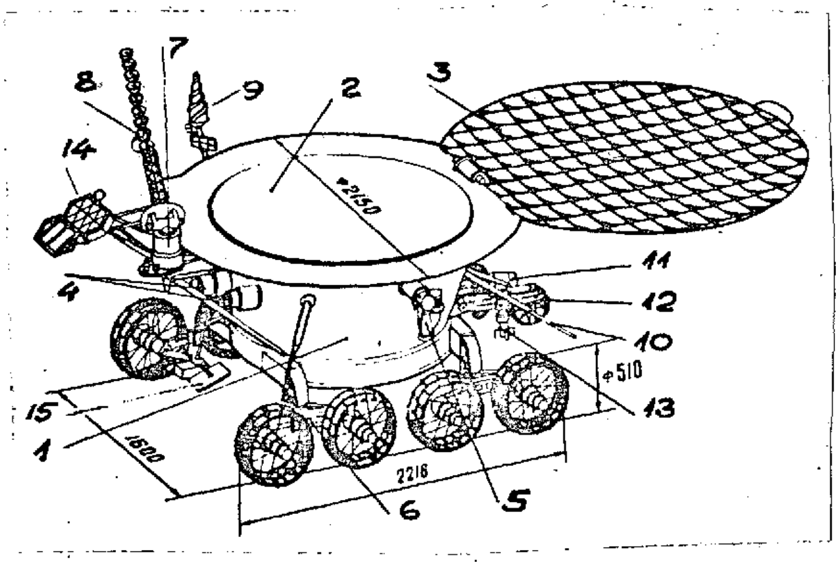

Fig. 4

"Lunokhod-1" (Fig. 4) consists of two basic parts: the instrument section of magnesium alloys and the wheeled landing gear. The weight of "Lunokhod-1" is 756 km. Explanations for the illustration: 1 - hermetically sealed instrument section; 2 - radiator-cooler; 3 - solar battery; 4 - windows of the small-frame television camera (the transmission of images necessary for the crew for control of the movement of the "Lunokhod" proceeds at a speed of 1 frame in 3-2 seconds); 5 - telephotocameras of vertical and horizontal view with a determiner of the local vertical; 6 - block of wheels of the landing gear; 7 - drive of the pencil-beam antenna; 8 - pencil-beam antenna; 9 - semidirectional antenna; 10 - one of the four whip aerials for reception of commands from earth; 11 - isotope source of thermal energy, heating the gas circulating inside the "Lunokhod" during the lunar night; 12 - the ninth wheel, serving to determine the path traversed; 13 - instrument for determining the physical-mechanical properties of the soil; 14 - optical angular reflector; 15 - "RIFMA" instrument. Dimensions are indicated in mm. /25

The self-propelling landing gear ensures a high degree of passability and reliable work with a minimum of its own weight and required electrical energy. The "Lunokhod" may move through loose, friable soil, overcome sharp rises and descents and also obstacles in the form of stones which are of the same dimensions as the moving part. The landing gear ensures movement at two speeds, forward and backward, turns in place and in motion. Each of the eight wheels has an individual drive (located in the hub of the wheel) and an independent torsion suspension. If there are overloads of the electrical engines of the wheels and extreme angles of bank and trim, the safety system of movement stops the "Lunokhod."

The system of electrical supply consists of a solar and a chemical battery. The elements of the solar battery are located in the interior side of the cover of the instrument section, which may be set up on command from earth at an angle of from 0° to 180° for maximum use of solar energy.

The system of thermal regulation maintains a temperature inside the instrument section within the prescribed limits (from -10° to +30°) at a pressure of from 735 to 770 mm Hg.

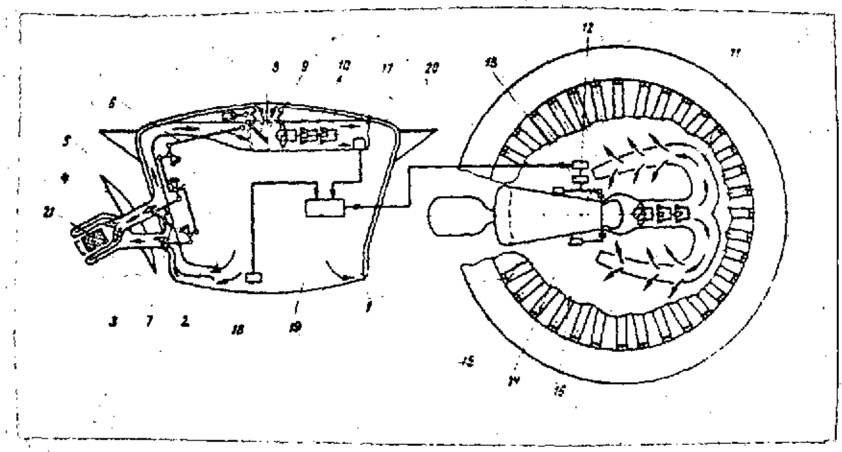

Fig. 5

In Fig. 5 the principles of the scheme of a bypass active circulation system of thermal regulation of the "Lunokhod" is presented: 1 - air pipes of the cold duct; 2 - air pipe of the hot duct; 3 - heating unit (HU); 4 - screen of the HU; 5 - dampers of the HU; 6 - control of the dampers of the HU; 7 - throttle valve; 8 - valve; 9 - unifying housing; 10 - three-stage ventilator; 11 - collector; 12 - drive of the valve; 13 - pitch mechanism; 14 - spring thrust; 15 - cam mechanism; 16 - sensor of angular changes; 17, 18 - sensitive elements of telemetric temperature sensors; 19 - radiator-cooler; 20 - collector of the blowing system of the HU; 21 - isotope heat source.

The thermal regime inside the "Lunokhod" is ensured through regulation of the temperature of the gas circulating inside the instrument section by constant work of the three-stage ventilator. With the help of a valve, the gas is directed into the hot or cold duct. The control of the valve is automatic, according to signals of the sensitive elements, or by radio commands. Some instruments are ventilated with the help of individual air-passage channels (output of gas of up to 1 m^3 per sec). The heating unit with an isotope heat source is installed outside of the thermal section. For protection of the "Lunokhod" during the period of the lunar day from the heat current flowing from the heating unit, a screen is set up between it and the body.

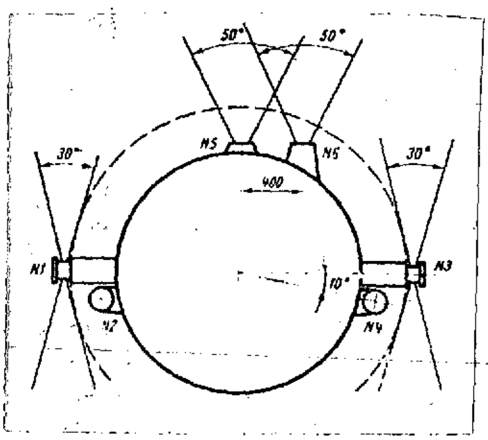

Fig. 6

In Fig. 6 the location of television cameras in the body of the "Lunokhod" is presented (in the plan): No. 1 and No. 3 - telephotocameras with vertical view; 2 and 4 - telephotocameras with horizontal view; 5 and 6 - cameras for short-frame television. The dotted line shows the outline of the upper covering of the body. In the sketch the angles of the field of vision of the cameras with vertical view and the camera of short-frame television are shown, and also the distance (mm) between the axes of the latter. /26

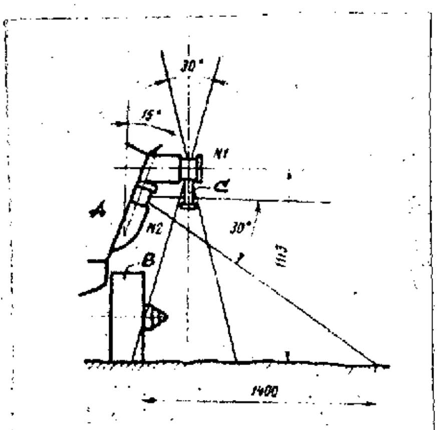

Fig. 7

In Figure 7--the location of the telephotocameras on the lateral part of the "Lunokhod": A - body of the "Lunokhod"; B - one of the wheels; C - determiner of the local vertical; No. 1 - vertical-view camera; 2 - horizontal-view camera. Its axis of inclination is at an angle of 15° to the local vertical; thus the boundary of the lower part of its field of vision passes 1,400 mm from the outer part of the wheel (when the "Lunokhod" is in a horizontal position). In the sketch the angles of the field of vision of each camera are also shown. The cameras on the opposite side of the body of the "Lunokhod" are similarly located.

The crew which directs the movement of the "Lunokhod" and its systems includes a commander, a driver, a navigator, an operator, and flight engineer. Choice of the regime of movement is made as a result of evaluation of television information and telemetric data on the amounts of bank, the differential, the path traversed, and the condition and regimes of work of the drives of the wheels. The crew underwent careful training and numerous instruction periods at ground lunar stations.

The scientific studies with the aid of "Lunokhod-1" lasted a long time and exceeded by several times the calculated working time. In only 10 lunar days, by August 16, 1971, 10,425 m were traversed. By the end of the 10th day all systems continued to function normally, which made it possible to continue the scientific experiments. These experiments included:

1. Topographical study of the locality on the basis of a photograph of the lunar landscape with the aid of television cameras and telemetric data. Topographical schemes of the route of movement were composed, as well as plans of the most interesting sectors and their topographical description. Stereoscopic panoramas were obtained.

2. The geological-morphological description of the region was made with the use of panoramic images, topographical descriptions, data on variations in the physical-mechanical and chemical properties of the soil and on the positions of the apparatus on the path of tracking. The region of the Sea of Showers which was studied is near the previously studied sea regions, which indicates the similarity of the regular formation and evolution of the lunar surface.

3. The "quick"-analysis of the chemical composition of the lunar soil was determined by the "RIFMA" spectrometric instrument (X-ray Isotope Fluorescent Method of Analysis). The isotope source installed onboard illuminated the lunar surface and caused corresponding X-ray radiation. The system of proportional counters with characteristic filters registered the energy spectrum and the intensity of the X-rays. Preliminary deciphering of /27
spectrograms obtained during the first three lunar days permitted the study of the chemical composition of the soil in 14 different places and the determination of the content of aluminum, calcium, silicon, iron, magnesium, titanium, and other elements. The general idea about regolith originating from rocks of basic basaltic composition was confirmed. Variations in chemical composition were discovered, depending on the morphological

characteristics of the section. X-ray radiation of a powerful solar flare was registered.

4. The physical-mechanical properties of lunar soil were studied with the aid of a special conical-blade punch, which was introduced into the soil every 15-20 m of the route and subsequently turned. Besides, the parameters of interaction of the wheels with the soil were measured and the images of the tracks of the wheels were observed on the television panoramas. It turned out that the soil consists of small-grained material like dusty volcanic sand. The thickness of the friable layer is 6-8 cm, but the upper 1-2 cm possess a more friable structure and a slighter bearing capacity, which fluctuates from 0.2 to 1.1 kg/cm^2. The resistance to revolving shearing action fluctuated from 0.02 to 0.09 kg/cm^2.

5. With the help of an X-ray telescope, consisting of two proportional counters for X-ray quanta for the field of energies of 2-10 KeV (wave length 1-6Å) with a collimator and filters, cosmic X-ray radiation was studied. Discrete X-ray sources lying outside the plane of the galaxy, two of them comparatively strong, were observed.

6. Radiometric apparatus was designed for measurement of the streams of solar and galactic cosmic rays (their composition, energy spectrum, angular distribution, etc.) and for control of the radiological situation during flight to the moon and on the lunar surface. The measurements were made in scales of energies which were inaccessible for study from the earth due to the screening action of the atmosphere.

Many times increases in the streams of protons, electrons, and alpha particles were registered. These data agree well with the results of measurements by a similar apparatus of the "Venera-7" station and data from ground observations. The previous conclusions about the low radioactivity of the surface of the moon were confirmed.

7. Together with French scientists, joint experiments were made on laser sounding of a special light-reflector installed on "Lunokhod-1," which was developed and produced in France. The method of laser sounding will permit an exact definition of the distance to the moon, the study of the moon's own rotation, and specification of the coordinates of individual areas on its surface. The sounding was carried out at the Crimean Astrophysical Observatory, where for this purpose a 2.6 m reflector was used, and also at the French observatory at Pique-du-Midi. Clearly reflected signals were registered.

Through launching of the "Luna-7" station and sending "Lunokhod-1" off to the moon, the basically new problem of the creation of an automatic laboratory capable of moving across the lunar surface and of making a broad complex of scientific-technical studies was solved.

"Zond-8" (No. 966--October 20, 1970). The goal of the launch was the making of physical studies on the route of the flight and in circumlunar space; photographing of the lunar surface, of the earth, and the moon at various distances; testing of the improved flight systems, units, and parts of the space apparatus.

On October 21 a session of photography of the earth was carried out at a distance of 65,000 km. During three hours of flight, television images of the earth were transmitted from on-board the station.

On October 22 at 9 h, 25 m, when the station was 250,000 km from the earth, a correction of the trajectory was made.

On October 24 the station completed a flight around the moon at a minimal distance from its surface of 1,120 km and began the return to earth.

On October 27 at 16 h, 55 m the station landed in the prescribed region of the Pacific Ocean, 730 km southeast of the Chagos Archipelago. The apparatus was taken onboard a Soviet ship of the search-and-rescue service.

For the purpose of testing one of the possible variations of return to earth of space apparatuses, the entrance of the "Zond-8" station into the earth's atmosphere was made from the northern hemisphere. Ground measuring stations located in the territory of the USSR controlled the approach of the station to the earth and a large part of the trajectory of its flight.

The program of scientific-technical studies and experiments was fully completed.

On the night of October 24-25 the station was photographed at a distance of 34,800 km at the high-mountain GAISh*Observatory (Zailiisk Alatau, 3,200 m above sea level).

V. The "Soyuz" Spaceship

"Soyuz-9" (No. 919--June 1, 1970). Started at 22 h Moscow time and went into orbit at 22 h, 09 m on the first of June. It

*P.K. Shternberg State Astronomical Institute.

was piloted by ship's commander, Hero of the Soviet Union, aviator-cosmonaut of the USSR, Colonel Nikolayev, Andriyan Grigor'yevich (making his second space flight, cf. "Vostok-3," No. 114) and flight-engineer, Candidate of Technical Sciences Sevast'yanov, Vitalii Ivanovich (flying for the first time). The weight of the ship was 6,590 kg. In design and arrangement, "Soyuz-9" was basically identical to the "Soyuz-6" ship (No. 853), but it had some differences. Its orbital section, in order to ensure lengthy flight, was supplied with containers with water and juice with a total capacity of 55 liters and with rations of food in jars, packages, and tubes.

In the orbital section were also placed articles of personal equipment, including personal hygiene devices, hammocks, sleeping sacks, special jackets with shock absorbers for executing a series of physical exercises, etc.

The purpose of the launch was the completion of a lengthy, solitary orbital flight and the execution of a large program of scientific-technial studies and experiments, including: study of the influence of factors of prolonged flight on man; observation and photographing of geological-geographic objects, of the continental and water surface in various regions of the earth for testing the method of using the data obtained in the national economy; observations, study, and photographing of atmospheric formations, of snow and ice cover, with the purpose of using data from the observations in operative and long-term meteorological forecasting; study of physical phenomena and processes in near-earth space; testing of manual and automatic systems of control, orientation, and stabilization of the ship; and testing of the autonomous navigation systems in various flight conditions.

After complete execution of the flight program, lasting 424 h, 58 m, 50 sec, at 14 h, 59 m, on June 19, 1970 "Soyuz-9" landed in the prescribed region, 75 km west of the city of Karaganda. An operative medical examination conducted at the site where crew was met showed that the cosmonauts endured the prolonged space flight well.

The results obtained were important for the further development of space technology and the solution of practical problems lying in the path of the creation and functioning of long-term orbital stations of importance to science and the national economy. The experiments conducted on the 188th circuit on the observation and photography of cloud formations in the western part of the water basin of the Indian Ocean, with the simultaneous participation of the scientific research ship "Academician Shirshov," from which balloon probes were launched in this region, and with the reception of television images from onboard the meteorological satellite "Meteor," is of interest. A second similar experiment was conducted in the 222nd-224th cycles when V. Sevast'yanov took photographs of geological-geographic objects in the regions of the south of the European part of the USSR, Kazakhstan, and in Western Siberia and, simultaneously with the space experiment in these regions photographs were made from geological survey aircraft. The comparison of the data obtained by various methods will permit a more accurate interpretation of the photographs received from space for the needs of the national economy. /29

The cosmonauts frequently reported on cyclones and thunderstorms which they had observed, on forest fires, dust storms, and storms at sea.

New methods and systems of astronavigation and maneuvering were tested. The systems of the spaceship and the scientific apparatus during the entire flight functioned faultlessly, creating in the living sections of the ship conditions close to those on the earth. The parameters of the microclimate varied within the following limits: total pressure, 732-890 mm Hg; partial pressure of oxygen, 157-285 mm Hg, carbon dioxide 1.3-10.7 mm Hg; the relative humidity, 50-57%; temperature, 17-28°C. The calorie content of the daily food rations was 2,700 kilocalories per man; water consumption, up to 2.9 liters per man per 24 hours.

The flight of the "Soyuz-9" spaceship showed that cosmonauts can work successfully under conditions of prolonged weightlessness. At the same time it turned out that the problem of readaptation to earth conditions after a prolonged stay in space requires serious attention on the part of scientists. On the first days after their return, the cosmonauts seemed to experience an overload of more than 2 units. This sensation lasted for 5-6 days. Difficulties in walking were noted, as well a disturbance of sleep during the first 4-5 nights. The restoration of weight occurred more slowly than after previous flights and took all of 11-13 days (during the time of the flight the cosmonauts' weight decreased: Nikolayev lost 2.7 kg and Sevast'yanov 4 kg due to loss of water, muscle fiber, and fat).

The parameters of the orbit indicated in the table relate to the third cycle. Later they changed in the following manner:

No. of cycle	Inclination to the equator	Period	Altitude at perigee	Altitude at apogee
14	51.7	89.05	213	267
17	51.7	89.5	247	266
50	51.722	89.398	241.638	261.064
181		89.1	231.2	246.7
208		88.8	215.1	231.4
286			189.9	202.3

B. AMERICAN ARTIFICIAL EARTH SATELLITES, SPACE PROBES, AND SPACESHIPS

I. Scientific Research Satellites

1. Satellites of the "Explorer" Series

The aerospace center of Italy and NASA in 1969 concluded an agreement on joint launches from an Italian "San Marco" platform (cf. Nos. 289 and 560) with the aid of the American "Scout" rocket of small American scientific research satellites. The agreement stipulates annual launches of "small astronomical satellites" ("SAS") into circular orbits, beginning in 1970, and of small scientific research satellites ("SSS"--Small Scientific Satellites) from 1971 on. In August, 1970 it was specified that up to the end of 1972 not less than four such satellites would be launched.

The floating platform of "San Marco" was produced in America. /30 It has a length of 90 m and a hangar 36.5 m long with an artificial climate is installed on it, designed for storing, assembling, and prestart tests of the "Scout" rocket, and also a device for launching it. The platform is located in the Indian Ocean near the shores of Kenya (2°56' south latitude, 40°12' east longitude).

At a distance of about 450 m from the "San Marco" platform, the platform of "Santa Rita" is located, produced by an Italian firm for ocean drilling and reequipped into a launch and tracking center and a center for receiving telemetry. Both platforms have their own energy devices and are connected by 23 cables.

Launches of satellites into equatorial orbits from platforms located near the equator are economically profitable: in this case a relatively cheap four-stage American "Scout" rocket may be used (costing $1.5 million), while for launching satellites into the same orbit from non-equatorial areas it is necessary to have a rocket of the Delta type (cost of more than $4.5 million).

"Explorer-42" ("SAS" No. 985--December 12, 1970)--a cylinder with total length of 1.16 m and a diameter of 0.56 m, with four panels of solar batteries. Weight about 142 kg. Consists of two units: the unit of service apparatus (in Fig. 8, below), identical for all satellites of this series (cylinder 0.51 m high and weighing 82 kg) and a unit of scientific apparatus (height, 0.56 m, weight, 68 kg; in the future it is planned to increase it to 90 kg).

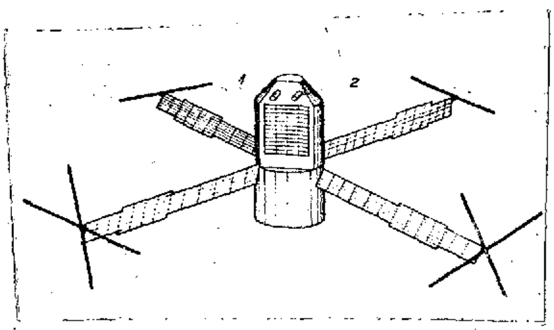

Fig. 8

In Fig. 8 the device of the "SAS-1" satellite is shown: 1 - star sensor; 2 - solar sensor.

The service apparatus of all the satellites of this series includes: an electromagnetic system of orientation; electromagnets for regulation of the speed of revolution (about 5 rev/h); a nutation damper; radio systems, and chemical sources of current. The satellite is also stabilized in revolution by a system of gyroscopes. Solar panels which ensure power of 27 watts are attached to the body. The dimension of the panels is about 3.9 m. On their faces are telemetric and command antennas. The transmission of information is in real time or from transcription. In the latter case the information accumulated during one (95 minutes) can be received in 3.4 m. The reception station is in the U.S.A., and, if necessary, in the Congo (Brazzaville), French Guiana, Kenya, on Ascension Island, and in Singapore.

The unit of scientific apparatus is designed for the study of X-ray radiation in a range of energies of 2-20 KeV. It is supplied with two similar X-ray telescopes with proportional counters, set up on opposite sides of the body, with collectors, one of which ensures a narrow field of view (1° x 1°), the other, a broad one (1° x 10°). (From other sources, correspondingly 0.5° x 0.5° and 5° x 5°).

The sky is scanned by the rotation of the satellite around an axis with a period of about 12 m. Every 24 h the direction of the axis of rotation changes on command from the earth. It is planned that in 1.5-2 months it will be possible to "examine" the entire heavenly sphere. The expected accuracy of determination of the positions of bright X-ray sources is up to 1 angular m, of weak ones--up to 15 m. It is expected that 50-100 times weaker sources will be discovered than are known at the present time.

Both instruments (each consists of 6 counters) were switched on on December 18, 1970 and scanned the same sector of the sky. In March 1971 it was reported that as a result of the data from the satellite, in the constellation of Cygnus a pulsar was discovered which emits X-rays (about 15 impulses per second). The source of this emission is assumed to be a neutron or collapsed star with a density of about 10 tons/cm^3.

The calculated period of active existence of the satellite is 6 months. The cost of the satellite is about $9 million.

2. The "OFO-1" Satellite

"OFO-1" (No. 972--November 9, 1970)--Orbiting Frog Otolith-- a study of the otolith organ of frogs in orbit--designed for study of the influence of alternating periods of weightlessness and accelerations on the otolithic organ under conditions of orbital flight. The satellite consisted of two sections: the lower in the form of a right truncated octagonal pyramid with electronic equipment, and the upper, conical with a spheroidal top. The maximum diameter was 0.762 m; length, 1,194 m; weight, 133 kg. /31

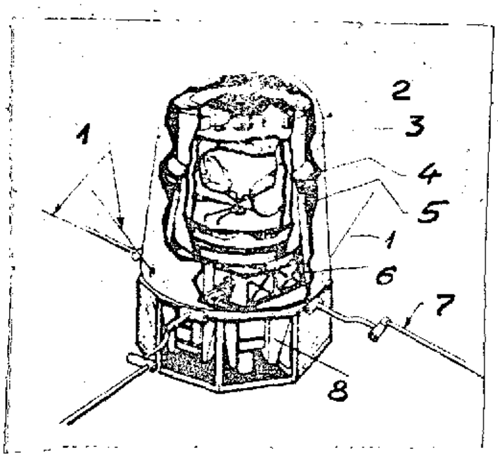

Fig. 9

In Fig. 9 the construction of the "OFO" satellite is shown: 1 - reception-transmission antenna; 2 - thermal shielding shell; 3 - container with frogs and apparatus; 4 - vibro-isolator; 5 - power frame of the container; 6 - accumulators; 7 - one of four folded back arms; 8 - radioelectronic system.

Inside the upper section, called the "FOEP block "(Frog Otolith Experiment Package) was installed a centrifuge with two frogs--male Rana Catesliana weighing about 350 g apiece, and also a life-support system. The otolithic organ of frogs is structuraly reminiscent of the otolithic organ of man, and therefore experiments with these amphibians are of interest for space biology and medicine. In the block was also placed equipment registering and directing into the telemetric system signals from sensors mounted in the nerve fibers coming from the sensory cells of the otolithic organ of the frogs, and also equipment for receiving electrocardiograms and thermal regulators, maintaining a water temperature within the limits of 14-17°C. This equipment was placed in a cylindrical container with a diameter and length of 45 cm and a weight of 41.5 kg. The block was sent to the starting complex five hours before the launch and was installed on the satellite an hour before the start. The frogs were deprived of the ability to move their extremities to avoid putting the sensors out of order and with the purpose of decreasing their metabolism. They could remain onboard the satellite immersed in water for a month. The speed of revolution of the centrifuge was up to 50 rpm.

The life-support system brought oxygen into the water and eliminated carbon dioxide. There was a reserve oxygen supply in a small balloon. The circulation of the water was done by a pump. A filter cleaned the water of biological waste products.

During the period of prestart preparation, 36 hours before the launch, 12 frogs out of 25 were chosen for the flight. During a 24-hour period microelectrodes were placed in their otolithic organs, two frogs then being chosen for flight and two for control. Transmission from onboard the satellite in real time ensured the receipt of information on the reaction of the otolithic organ to the influence of vibrations and accelerations in the exit sector and later on the influence of weightlessness. The working cycles of the centrifuge lasted about 8 m. and consisted of these periods: absence of gravity (acceleration up to 0.001 units), 1 m; transitional period (untwisting of the centrifuge), about 8 sec; action of constant force of gravity (up to 0.5 units), about 14 sec; transitional period, about 8 sec; appraisal of results, about 6 m. In the first three hours of flight these cycles were repeated every 30 m, then, to the end of the first twenty-four hours, every hour. Then passive flight, analysis of the information, and development of the further program took place.

The calculated duration of the experiment was 5 days. During this period, as a result of the lowered physiological activity, the frogs could get along without food; therefore, a system of food supply was not planned. On conclusion of the experiment the frogs were killed by putting carbon dioxide into the water instead of oxygen. The life-support system allowed a prolongation of the experiment of up to 65 days. It turned out /32 that as early as 3 days of flight the otolithic organs of the frogs became completely adapted to conditions of weightlessness. The information was received by two stations in the USA and also by stations in the UAR, the Malagasy Republic, Australia, Chile, Ecuador, and in the Hawaiian Islands. Expenditures on the experiment were about $3 million. The launch was planned for August but was postponed until November. In the experiment scientists from Italy (Milan University) took part.

An unexpectedly slow course of adaptive reactions was discovered in the first network of the inner ear: adaptation to conditions of weightlessness began only after three days of flight. This fact helps to answer the question as to why the cosmonauts at an early stage of flight typically experience unpleasant sensations. Apparently the need for creating artificial gravity on spaceships is confirmed.

Together with the "OFO" satellite, a research statellite "RM" (cf. below) was put into orbit.

3. The "RM" Satellite

"RM" (No. 974--November 9, 1970)--"Radiation Meteoroid"--study of radiation and meteor danger. The satellite is designed for tests of the perfected systems for registration of radiation doses and also for determining the danger of collisions with meteor particles, the density of their stream, the direction, and speed of their movement.

Launched together with the "OFO-1" satellite (see above), but, in contrast to the latter, it did not separate from the last stage. The length of the satellite together with the last (fourth) stage of the "Scout-B" rocket, was 1,676 m; the diameter, 0.762 m; the weight, 45 kg. And the payload (the satellite and its service systems) was 21 kg.

The scientific apparatus consisted of a perfected dosimetric system, including a spectrometer, for registration of electrons with energies of 0.6-4.0 MeV and protons with energies of from MeV to several hundred MeV. The data were stored in a recording device and were transmitted in fly-by over the tracking station; three ionization chambers filled with a mixture of argon and helium for the registration of radiation from 0.01 to 100 rads per hour; two flat detectors of micrometeors, registering the density of the particle stream, their direction, and speed of movement. Each detector is a square disc 200 x 200 mm, composed of thin-filmed sensors 25 mm wide each. The sensors were made of four layers of synthetic tape (polysulfon) 1,000 Å thick, covered on the interior with a layer of gold 200 Å thick and on the outside, with a layer of aluminum 1,000 Å thick. Thus, the total thickness of each sensor is around 0.005 mm. They are tested when the particle strikes a mass of from 10^{-14} and larger. Both detectors penetrate a particle with a mass of from 10^{-12} g. The detectors are located parallel at a distance of 75 mm from each other, and therefore it is possible to determine the speed and direction of the particles.

The energy supply sources are nickel-cadmium accumulators, charged by a solar battery of about 25 V, located on the external surface of the service section of the satellite (length of the section, 0.37 m).

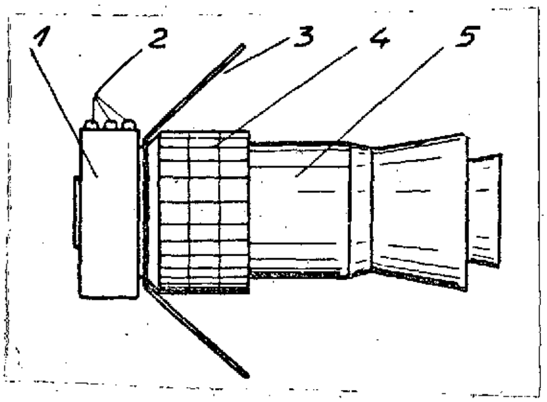

Fig. 10

In Fig. 10: 1 - block of the scientific apparatus; 2 - sensors of the position of the satellite in space; 3 - antennas; 4-solar battery; 5 - last stage of the rocket.

The radiotechnical system included a block of antennas, command and telemetry blocks and radio beacons. The information was transmitted chiefly to a station in Rosman (state of North Carolina) and could be received by the other stations enumerated above (cf. "OFO-1" satellite). In tracking and /33
receiving information, preference was given to the "OFO-1" satellite.

4. Orbital Astronomical Observatory

"OAO-3" ("OAO-B")--perfected orbital astronomical observatory (cf. No. 759). In comparison with "OAO-2," the apparatus and service systems were significantly improved, and the dimensions and weight were increased (maximum diameter, 2.1 m; weight, 2,024 kg). The basic instrument--a telescope of the Kassergen system with a focusing distance of 483 cm and a mirror with a diameter of 96.5 cm--was designed for study of stars 8 times weaker than those studied by the "OAO-2." The mirror of the telescope was made of beryllium and with a thickness of 3.8 cm it weighed 56 kg. The complex of astronomical apparatus included: a Wright-Schmidt spectrometer for radiations in a range of 1,000-4,000 Å, six radiation counters in a range of 1,050-4,260 Å, and a sensor for registration of radiations in the visible part of the spectrum. The apparatus was produced in the USA and England. The guidance and stabilization system ensured accuracy within the limits of one angular second. In this system are six star sensors and nine gyroscopes. The new inertial system possessed a drift of 10 sec/hr, which is 30 times better than the analogous system on the "OAO-2." The effective sun screen gave the opportunity for the apparatus to work over the lighted side of the earth also. A new memory device ensured the storage of a volume of information 5 times greater than was set up on the "OAO-2." Improvements were introduced into the units of the electronic apparatus and into the ground tracking network. The accumulators were charged by two solar panels with 52,000 elements (power of up to 1,000 V). It was expected that the satellite will permit the study of 14,000 stars in the first year; its calculated time of active existence is four years. It cost $98 million.

The launch was made on November 30, 1970. Four m, 16 sec after the start, in accordance with the program, the protective cone was to have been cast off, but it did not separate and the last stage did not achieve the calculated speed. The satellite together with the stage burned in the atmosphere.

Thus, of the three orbital astronomical observatories, the first and the third did not go into orbit. But the second observatory (No. 759--December 7, 1968) is working very successfully, more than doubling the calculated time limit for active existence (more than two years instead of one year). By means of it much new information on the stars, nebulae, galaxies, planets, and comets has been obtained.

II. Meteorological Satellites

Launches of meteorological satellites in the USA began in 1960 (cf. "Tiros-1," No. 26--April 1, 1960). Up to August, 1969 10 satellites of the "Tiros" series were launched. Their term of service extended from 89 days ("Tiros-1") to 1,809 days ("Tiros-7," 174--June 19, 1963). They transmitted more than 650,000 images to the earth. In 1966 launches of the "ESSA" satellites began ("ESSA-1," No. 412--February 3, 1966), which differ little from the "Tiros" satellites. Up to February, 1969, nine such satellites were put into orbit. During these years they transmitted to the earth without interruption meteorological information which embraced the entire planet. By March, 1970 from the "ESSA" satellites about 642,000 photographs were obtained, and by this time five satellites of this series ("ESSA-2," No. 420; "ESSA-5," No. 558; "ESSA-6," No. 636, "ESSA-8," No. 763, and "ESSA-9," No. 784) continued to function.

Since 1960 the "Tiros" and "ESSA" satellites followed the development of 400 oceanic storms, typhoons, and hurricanes; with their help maps of the ice situation in the Great Lakes and on important sea routes were composed regularly.

From August, 1970 through April, 1970 4 "Nimbus" satellites were launched, from which about 400,000 images were received. Meteorological problems are solved by the "ATS-1" satellites (No. 514) and "ATS-3" (I 633), which have transmitted about 20,000 global images of the earth from the altitude of a synchronous orbit, and color images are received from the "ATS-3" satellite.

Since 1966 the development of more perfected meteorological satellites of the USA of the "second generation" began-"Tiros-M" or "ITOS" (Improved Tiros Operations Satellite). On such satellites television cameras and sensors are set up, which partially underwent tests on "Nimbus" satellites. It is expected that in connection with the great extent of the earth's surface and the doubly greater information, and also with the lengthy time of the active existence of the "ITOS" satellite, they will ensure a savings of not less than $14 million per year in comparison with the "Tiros" satellites.

1. The Satellite "ITOS-1" ("Tiros-M")

"ITOS-1" (No. 886--January 23, 1970). Another name was "Tiros-M" (during development). A paralleliped with a square base 1,016 x 1,016 m, 1,245 m long and weighing 306.18 kg (weight of the scientific equipment is 90 kg). In Fig. 11 the composition of the satellite is shown: 1 - mirror and horizon sensors; 2 - flywheel of the stabilization system; 3 - instrument for study of the proton component of solar radiation (solar proton monitor); 4 - louvers for the system of thermal regulation; 5 - panels of solar batteries 0.91 x 1.65 m (solar elements located on the opposite side); 6 - antennas of the transmitter of solar images of the earth in real time at a frequency of 137.5 mHz; 7 - solar sensor; 8 - antennas of the command receiver at a frequency of 148.5 mHz and of the radio beacon; 9 - earth sensor; 10 - tourniquet antenna; 11 - television cameras of the ART system; 12 - television

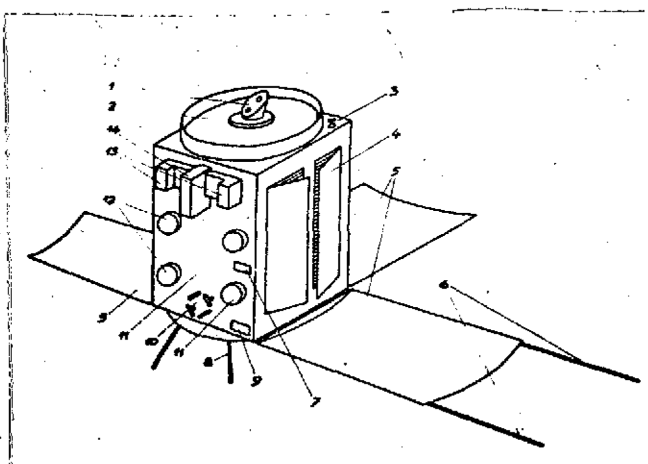

Fig. 11

cameras of the AVCS system; 13 - radiometers; 14 - radiometer for measuring the albedo of the earth.

The satellite was oriented by three axes and stabilized (accuracy of 1°) with the help of two magnetic devices and a special "Stablite" device, at the basis of which is a flywheel which turns at a speed of 150 rpm. The longitudinal axis of the body of the satellite is perpendicular to the orbit; the edge with the lenses of the television cameras and the radiometers is constantly directed toward the earth. For initial orientation a solar sensor (7) is used, then pitching and bank are determined with the help of four infrared horizon sensors and a scanning mirror, set up on the flywheel (1). On three solar panels with a total area of 4.7 m^2 were placed 10,000 solar elements, ensuring a power of 500 V (according to other sources, 250 V). The drive which changes the position of the flaps of the louvers (4) is based on a change in the volume of liquid under the influence of the surrounding temperature. Developing force of 1.83-3.2 kg, temperature adjustments from -10 to +10°, 20 ± 1.5° and 35-55°. Operating life 10^7 cycles, calculated reliability, 0.995.

Scientific apparatus: two television cameras of the ART [Automatic Range Tracking] system (described in preceding issues) for observation of the cloud cover in the daytime and at night respectively in the visible and infrared,part of the spectrum and transmission in real time of from 1 to 11 images during one revolution of the satellite with resolution in the center of the film of 3.2 km. The dimension of the area transmitted in one image is about 2,560 x 2,160 km. For neighboring a coverage circuits of about 30% is ensured. Two two-channel scanning infrared radiometers for observations of the cloud cover during the day (in a range of 0.52-0.73 um), and also during the day and at night (in a range of 10.5-12.5 um). The resolution in the center of the frame in the daytime is 3.6 km, at night about 7.2 km. The angle of scanning is 150°, which from the altitude of orbit ensures observations of the earth from horizon to horizon. /35
The radiometers in each loop work for 71 min and allow a determination of temperature of the underlying surface and the upper layer of the clouds, and according to these data the altitude of the upper layer of the cloud cover is calculated. The data from the radiometers can be transmitted in real time also from the transcription. Information in real time (from ART and the radiometers) is received in 50 countries where about 500 stations are located, including directly in many airports of the world. The equipment of the receiving stations is simple, and in the future it is planned to receive images directly onboard aircraft day and night;

- two television cameras of the AVCS [Advanced Vidicon Camera Subsystem] system (described in preceding issues) for observations of the cloud cover in the daytime in the visible and infrared part of the spectrum and transmission of images from transcription to two stations of the USA. During one loop 11 images are transmitted with a resolution in the center of 3.2 km. On command from the ground, the images are transmitted to a ground station. Measurement of the area covered by a photograph 2,560 x 2,560 km, which ensures coverage for neighboring circuits of about 50%;

- four flat detectors for measurement of the components of the heat balance of the earth-atmosphere system;

- monitor of solar protons for measurement of the proton stream reaching the orbit of the satellite. Information about the proton streams is necessary for the study of the influence of solar activity on the weather, and also for high-altitude (supersonic, including civil) aviation, for planning launches of spaceships, and for radio communications service.

Up to June 15, 1970 pre-operations tests were conducted of "ITOS-1," after which it was put into operation for the Command of the Service for Scientific Information on the Environment ("ESSA"). The cost of development and production of the first "ITOS" satellite was $20 million; of its launch, $5 million. In the future the cost of producing and launching these satellites will be $5.5 million. It is planned to produce 5 more such satellites. It is expected that they will be the most long-lived and therefore the most economical of the weather satellites of the USA.

Simultaneously with the "ITOS" satellite, an additional load, the satellite "Oscar-5" (cf. p. 81) was put into orbit).

2. The Satellite "NOAA"

"NOAA" (No. 984--December 11, 1970). Another name is "ITOS-B." Repeat of the launch of the "ITOS" satellite. After launch and checking in orbit it was put at the disposal of the new National Oceanic and Atmospheric Administration, NOAA, hence its name. Design and tasks--cf. "ITOS-1" satellite (No. 886). Weight--306 kg.

3. "Nimbus-4" Satellite

"Nimbus-4" (No. 903--April 8, 1970). Repeat of the launch of the meteorological satellite of the "Nimbus" series (cf. No.

805). Design basically unchanged, weight--620 kg. Basic tasks: testing of instruments designed for installation on proposed meteorological satellites and study of the atmosphere of the earth, in particular, collection of quantitative data on vertical distribution of temperature, water vapor, and ozone.

Scientific apparatus:

1. Infrared interferometrical spectrometer IRIS (cf. No. 805).

2. Infrared spectrometer SIRS (cf. No. 805).

3. IRLS system. This system, already successfully tested on the "Nimbus-3" satellite (No. 805), was designed to receive data from: stationary stations of NASA (Goddard Center for Space Research, state of Maryland); from the ground station of NASA, transmitted from Vandenberg Base (California) to the east coast of the USA; from a naval station on an oceanographic buoy, standing at anchor near the shores of Puerto Rico; from the stationary naval station in the Bermuda Islands; from the oceanographic institute station at Georges Bank near Cape Cod (Labrador) [sic]; from the station for control of commercial fishing industries in the northern part of the Pacific Ocean (south of Alaska); from the naval station (location not indicated), used within the framework of the program for testing rescue operations in the air and at sea; from the National Scientific Fleet station on the research vessel "Hero," in the region of the Antarctic; from the Smithsonian Institute station, set up on the collar of an elk, grazing in Jackson Hole (state of Wyoming, cf. also No. 805); from the station of the organization of ESSA in the region of the North Magnetic Pole (later this station was transferred to the Antarctic); and from the Scripps Institute station in the regions of the North and South Magnetic Poles. Furthermore, data will be received from NASA stations on balloon probes. These balloons are launched according to the GHOST program (Global Horizontal Sounding Technique--apparatus for global horizontal sounding of the atmosphere) from Ascension Island. The balloons are made of non-stretchable film, and, having a constant volume, they fly according to the air current at a prescribed altitude of 20-24 km. They have sensors of temperature and pressure, and also receivers and transmitters. On command from the satellite, the balloon transmits the results of measurements of temperature and pressure. These results, and also the time for sending the requested signal and receiving an answer, are fixed on the satellite and are stored for transmission to earth, which allows the calculation of the position of the balloon during the communications session with an accuracy of up to 3.2 km. Following the path of the balloon, it is possible to determine the time for the next session with it, which is placed into the programming device of the

satellite. By the middle of October, 1970 there were 7 balloons in flight and four of them were transmitting information. The use of balloons was somewhat difficult, due to the possibility of their icing at low altitudes and the danger of collision with aircraft. It is planned to construct balloons of very thin film, easily torn in collision and not creating danger when the casing is sucked into the engine of aircraft (cf. also the "PEOLE" satellite, p. 72).

4. Sensor of the ultraviolet radiation of the sun, MUSE (cf. No. 805).

5. Television camera of the IDC system for receiving images in the daytime (cf. No. 805).

6. Ultraviolet spectrometer of return scattering (BUV--Backscatter Ultraviolet Spectrometer) for global registration of the distribution of ozone in the atmosphere.

7. Spectrometers with filter and a photometric wedge (FWS--Filter Wedge Spectrometer) for determining the total content and vertical distribution of water vapor in the atmosphere.

8. Infrared radiometer with selective sensor (SCR--Selective Chopper Radiometer), produced in England (Reading and Oxford Universities) for determination of the temperature profile of the atmosphere at six altitudes with a spatial resolution of about 10 km and a maximum altitude of measurement of about 64 km. The instrument embraces a field along a trajectory 11 km in length and 110 km in width. It turns out to be significantly more effective than the American ones: it does not create disturbance for the telemetric system (the American radiometers created such a high level of interference that the signals from the satellites could not be deciphered); a significantly large range of altitudes, within the limits of which the temperature is determined; and a resolution almost twice as great (up to 1°C). The radiometer registers the radiation in six very narrow intervals in a field of 15 km and ensures the receipt of data on temperature in a global scale twice a day. The data are noted down by a flight device and are transmitted to the receiving station in Alaska. The installation of such instruments is planned on all American meteorological satellites and on the meteorological satellies "X-4," developed in England. The number of channels in the future will be increased to 16; the dimensions and weight of the instrument will be decreased.

9. An infrared radiometer (THIR--Temperature Humidity Infrared Radiometer) for measuring infrared radiation of the earth in the daytime and at night and transmittal of the images of the cloud cover, three dimensional mapping of the cloud cover,

composition of a temperature chart of the upper layer of the cloud cover of the surface of the earth and the oceans, determination of the relative humidity, and supplying information to other experiments.

Experiments 6-9 were executed for the first time on a satellite of the USA.

In contrast to the first satellites of this series, the "Nimbus-4" was equipped with basic and reserve orientation systems. As a basic system, an improved orientation system with respect to three axes was used, which ensures constant orientation relative to the earth with an accuracy of 1°. This system ensures initial and repeated inclusion of the earth at any position of the satellite. In case this system goes out of commission, the orientation is ensured by a reserve gravitational system, using a sliding aerial 15 m in length. The command system has also been improved and ensures the receipt of 512 commands. Information from the satellite comes through 576 channels in analog form and through 320 in digital form.

Sixteen stations ensure the tracking of the satellite. The receipt of television information in real time may be done by more than 500 stations, including more than 80 stations beyond the bounds of the USA. To these stations, in particular, information is transmitted in real time from the IDC and THIR instruments. The rest of the scientific information is transmitted to two stations in the USA (in Alaska and in the state of North Carolina).

On the basis of the successful experience in the creation of meteorological satellites, satellites in the USA are being developed for the study of natural resources. It was noted that, while until recently satellite weather information could be used only within the framework of qualitative synoptic analysis and forecasting, recently ("Nimbus" satellites 2 and 4) success was attained in making the first steps toward receiving quantitative data (vertical profiles of temperature) necessary for numerical forecasts of the weather.

Simultaneously with the "Nimbus-4" satellite, as an additional load, the geodetic military "TORO-1" satellite (cf. p. 60) was put into orbit.

III. Communications Satellites

1. The "Intelsat-3" Sstellites

In 1970 launches of the "Intelsat-3" satellites of the international consortium "Intelsat" (cf. Nos. 765 and 779) continued. The development of this consortium proceeded swiftly during the first years after its organization: in 1970 the number of countries participating reached 76 (by the end of 1974, 19) and by the end of 1970, four satellites were being operated in synchronous orbits (cf. below) and 48 receiving stations in 35 countries. The total sum of the capital investments of the consortium from 1965 through 1971 was about $600 million. But in 1969-1970 difficulties were perceived for its further development, the chief reason for which is the hegemony of the American corporation "Comsat," which owns 53% of all the stock. Besides, a number of the largest firms connected with "Comsat" continue the development of cable communications lines, considering them more profitable. Thus, according to estimates of representatives of these firms, the cost of a satellite communication line from New York to San Francisco is $154.9 million, and its annual operational expenditures are $48.9 million, while the cost of a cable line is correspondingly $114 million and $34.2 million. Inasmuch as a number of countries are connected by underwater cables, the satellite lines can serve only as an addition to the cable lines and can be used during "peak hours."

It is expected, however, that with the launch of the "Intelsat-4" satellites in 1971 (these satellites will be able to service 12 television and 6,000 telephone channels simultaneously), the cost of telephone communications through 6,000 channels will be about $28 million, while the cost of the cable line through 720 channels was $70 million in 1970.

On February 20, 1970 a ground station of the satellite network was officially opened in Australia (city of Sedun)--the third in the country (after the stations in the cities of Morn and Carnarvon). The cost of the station was $12 million. It ensures communications with almost all the countries of Asia, but basically is used for strengthening communications with England. The equipment of all the Australian stations is identical and is produced by Japanese and American firms. The usual cost of a station for receiving "Intelsat" signals is from $1 million to $7 million.

"Intelsat-3" ("F-6," No. 881--January 15, 1970). The launch was postponed three times due to unfavorable weather conditions and a fourth time due to difficulties with the rocket-carrier.

The construction and technical capabilities of the satellites of this series were described in preceding issues.

Weight was 137 kg. Put into synchronous orbit over the Atlantic Ocean (over a point with west longitude of 24.5°). Operation began on January 23, 1970. /38

"Intelsat-3" ("F-7," No. 910--April 23, 1970). The launch was planned in February, but was postponed. The purpose was a substitution for the "F-2" satellite (No. 765), which was over the Atlantic Ocean and transferred to NASA.

The launch turned out to be not completely successful: the engines of the last stage switched on prematurely, the satellite went out into insufficiently high orbit (apogee of 33,700 km instead of the calculated 36,500 km) and in order to change it it was necessary to use 2/3 of the fuel of the correction engine. Therefore, the satellite apparently will not be able to function for five years, as was planned.

"Intelsat-3" ("F-8," No. 933--July 23, 1970). The launch was planned for April-May, but it was postponed many times and nevertheless proved unsuccessful. Twenty-seven hours after launch, at 2 h, 15 m world time on July 25 the apogee engine was switched on, which was to work 25 sec and to transfer the satellite to synchronous orbit. But 14.5 sec after switching on the engine, the transmittal of telemetric information ceased and attempts to restore communications with the satellite proved unsuccessful. It was proposed to leave the satellite as a reserve over the Pacific and Indian Oceans (the calculated position--over Indonesia). The cost of the launch was $13 million, including $8 million for the cost of the satellite.

Thus, out of 8 launches of "Intelsat-3" satellites, three turned out to be unsuccessful.

By the end of 1970 the following commercial communications satellites of the USA (besides the satellites of the military communications systems) were in synchronous orbit and working or in reserve: over the Atlantic Ocean--"Early Bird" (No. 320), reserve; "Intelsat-2" (No. 548), reserve; "Intelsat-3" (No. 765), transferred to NASA; "Intelsat-3" (No. 881), working; and "Intelsat-3" (No. 910), working.

Over the Pacific Ocean--"Intelsat-2" (No. 523), reserve; "Intelsat-2" (No. 616), transferred to NASA; "Intelsat-3" (No. 813), 900 channels out of 1,200 working.

Over the Indian Ocean--"Intelsat-3" (No. 779), about 100 channels out of 1,200 working, due to the small number of stations in Asia, Africa, and the countries of the Far East.

IV. Geodetic Satellites

The "Toro-1" Satellite

"TORO-1" (No. 903--April 8, 1970). Continuation of launches of geodetic satellites of the US Department of Defense, designed for testing of new technical equipment, and ensuring an exact definition of the coordinates of objects on the surface of the earth.

In the construction of "TORO-1" several modified units of the "Secor" geodetic satellites (cf. "Secor-13," No. 805, and "Secor-1," No. 206) were used, and a rectangular body with solar panels and nine antennas moving out in orbit. On board were installed a receiver-answering device and a telemetric transmitter. The weight of the satellite is 18 kg. Modified ground stations are designated for tracking the "TORO-1" satellite, which are used within the framework of the "Secor" program.

As additional load the Torad ("Agena-D") rockets were launched during launch of the "Nimbus-4" satellite (p. 54) separated from the last (second) stage of the rocket 46.5 minutes after the "Nimbus-4" satellite.

V. Satellites for Testing of Service Systems

1. The "SERT-2" Rocket

In the USA (as in other countries) over the course of a number of years ground and flight tests of promising electrical rocket engines have been progressing, especially ion engines, in which the working body is ionized vapors of alkali earth metals and other elements (mercury, argon, etc.), accelerated by a strong electrostatic field to speeds of tens of km per sec. The thrust is determined by the total mass of outflowing ions and the electrical power of the jet stream and varies from small amounts to hundreds of grams. In the USA flight tests were conducted twice on the SERT program (Space Electric Rocket Test--testing of electrical rocket engines in space). /39

On July 20, 1964 on the "Scout" ROCKET the first tests in the USA of the "SERT-1" device were conducted on a ballistic trajectory at an altitude of up to 4,000 km. The engine had a thrust of 2.3 g (according to other data, 2.9 g) and weighed 5.3 kg (the weight of the entire device was about 170 kg). As a working body vapors of mercury were tested. The engine worked over a period of 30 m (flight lasted 50 m). On command from earth the engine switched on and off many times.

In 1965 on the "SNAP-10A" satellite (No. 319) tests of the ion engine were unsuccessful. Tests of ion engines were also made on the "ATS-5" satellite (No. 837).

"SERT-2" (No. 887--February 4, 1970)--testing of an experimental device of the NASA St. Louis research center, consisting of two improved mercury ion engines and a solar energy device, mounted on a modernized "Agena" rocket (Fig. 11).

The assignments of the launch: tests of the engines in orbital flight, in particular, for changing the orbit; study of the influence of its stream on the solar battery; study of radio interference created by the working engine for communications in a range of frequencies of 300-700 mHz, 1,680-1,720 mHz, and 2,090-2,130 mHz. The calculated duration of work of each engine was 6 months.

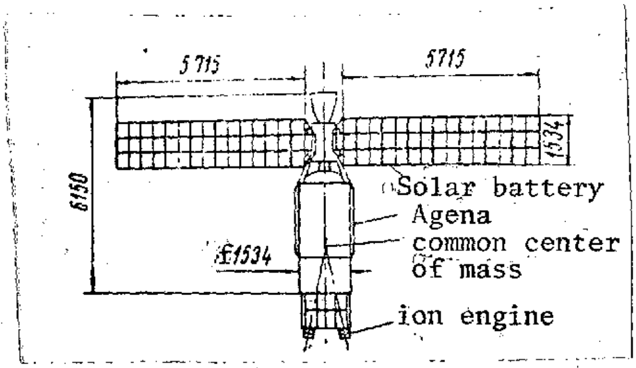

Fig. 12

For dimensions of the device and location of the engines, cf. Fig. 12. Its weight was 1,435 kg, including weight of the constructions of 282 kg; of the service systems unit, 220 kg; of the empty rocket, 740 kg; and of the solar battery, 193 kg. The maximum thrust of each engine was 2.7 g; the speed of flow of ionized mercury vapors was 80 km/sec; and the reserve of working fluid was 13.1 kg apiece. The weight of the engine was 4.5 kg. Electrical feeding was supplied by a solar battery with a total area of 17.4 m², consisting of 33,000 elements and developing a power of 1,471 V. The system of transformation of energy (weight of 14.5 kg) for nine equal units yields electrical supply with a voltage of from 4.5 in alternating current to 3,000 in direct current.

In accordance with the program, the first engine was to work for 6 months, then to stop work in connection with the entrance of the satellite into the earth's shadow. After emerging from the shadow, it was planned to switch on the second engine for 8 months.

On February 10 a testing switching of the engines was conducted in a range of 30-80% maximum thrust.

On February 14 the first engine was put into conditions of full working thrust. After the first days of work it turned out that the efficiency of the experimental solar elements mounted near the ion bundle was reduced by 67% as a result of settling on them of dust-like particles of molybdenum, of which the network accelerating the ions consists, destroyed under the influence of the ion stream.

On March 7 the satellite came into a band of complete solar eclipse. The ion engine was switched off in order to avert its possible injury as a result of a sharp decrease in voltage.

By May 17 the first engine had worked more than 2,000 hours and ensured an increase in altitude of orbit of the satellite by 47 km (in the future the engine worked so that the altitude of the orbit of the satellite decreased).

On July 23 the first engine went out of order, having worked a total of 3,785 hours (more than 5 months). Seven unsuccessful /40 attempts were made to switch it on.

On July 24 the second engine was switched on. On August 31, an hour before the entrance of the satellite into the earth's shadow, it was switched off and again switched on on September 2, after emergence from the shadow. The engine developed the calculated thrust. Before the repeated switching on of the second engine four more unsuccessful attempts were made to switch on the first engine. Apparently a short circuit developed in it between the two accelerating networks as a result of a metal particle falling between them, torn away from one of the networks under the influence of ion erosion.

On October 17, the second engine unexpectedly stopped work and again could not be switched on. Due to an overload in the electrical circuit, the flight system's electrical supply was automatically switched on. Thus, the second engine worked a total of 2,011 hours (about 3 months).

Despite the premature failure of both engines, tests demonstrated the efficiency of using ion engines for changing the orbits of space machines and their suitability for ensuring flights to the planets.

During the time of the experiment, the satellite was transferred to an orbit 467 km in altitude, and thus it was lowered by more than 600 km in comparison with the initial one. The system of neutralization of the ion stream worked successfully.

Substantial disruptions in radio communications with ground stations were not observed.

VI. The "Apollo" Spaceships

"Apollo-13" (No. 970--April 11, 1970). The crew consisted of: ship's commander James A. Lovell, age 42, completing his fourth flight ("Gemini-7," December, 1965; "Gemini-12," November, 1966; "Apollo-8," December 1968--participating in these three flights, Lovell spent a total of 572 h, 10 m in outer space); in the command module, John L. Schweikert, 39 years old, in flight for the first time; pilot of the lunar module, Fred W. Hesse, 37 years old, in flight for the first time (neither is a member of the armed forces).

The basic tasks of the flight: study and collection of samples of lunar soil in the mountainous region near the Fra Mauro crater (3° south latitude, 17° west longitude, 175 km east of the landing place of the "Apollo-12" crew), where it was planned to find intrusive lunar rocks thrown off as a result of the formation of the crater of Copernicus and the Sea of Rains; setting up and putting into motion a complex of scientific apparatus, the "ALSEP-3," somewhat modified in comparison with a similar complex installed by the crew of "Apollo-12" (cf. No. 867) and equipped with a radioisotope device with a power of about 69 V using plutonium-238; determination of the ability of a man to work under lunar conditions during 35 hours on the moon and with two walks on its surface; obtaining of photographs of proposed landing spots for subsequent crews.

The weight of the command module (code name "Odyssey") was 5,702 kg; of the lunar module (code name "Aquarius"), 15,192 kg. The total weight of the spaceship with fuel was 44,128 kg (according to data presented in the "COSPAR" Bulletin).

The basic units of the ship did not undergo any substantial changes. There were several improved pressure suits; for quenching the cosmonauts' thirst on the moon, 227 g of water were placed inside the helmet's tanks with a nozzle which could be easily grasped by the cosmonaut by turning his head. In connection with the more complex landing conditions in an extremely rough terrain, it was decided to transfer "Apollo-13" from the initial circular selenocentric orbit at an altitude of 96 km to an elliptical one with a pericynthion of 15 km and an aposelenion of 96 km. The division of the lunar unit in pericynthion would ensure a savings of fuel for 14-17 sec of work of the engine and greater possibilities for horizontal maneuvering.

In the "ALSEP-3" complex were included: a seismometer; an instrument for measuring the flow of heat from the depths of the moon and the thermal conductivity of the lunar soil; an instrument for registration of electrons and protons, with the purpose of determining the action of the solar wind on the lunar surface; a sensor for measuring the density of the lunar atmosphere; an instrument for trapping lunar dust. For delivering the "ALSEP-3" set to the installation site and for transporting samples of the lunar soil, it was planned to use a two-wheeled hand cart ("Rickshaw"). /41

The cosmonauts were equipped with devices for drilling holes with a diameter of 2.9 cm and a depth of up to 3 m in the lunar soil. In the holes it was proposed to set up sensors for determining the gradient of the thermal stream (period of work, 45 days) and thermal conductivity (period of work, 1 year). From the holes it was planned to extract and deliver to the earth columns of soil. The sounds of drilling were to be transmitted to earth, so that specialists from the Space Center could guide this experiment. For study of the mechanical properties of the soil, the cosmonauts were to dig a hole to a depth of about 60 cm and form the soil extracted in a cone, onto which one of the cosmonauts was to jump and the other to photograph him. The program planned the study of the possibility of radio communications outside the bounds of direct visibility, at a distance of about 800 m. For study of the seismic properties of the moon, it was proposed to drop onto its surface the last stage of the "Saturn-5" rocket, weighing 14 t (trotyl equivalent, about 10 t), at a distance of 350-700 m from the seismometers set up by the crew of "Apollo-12," and also the takeoff stage of the lunar module (weight, 2.5 t). This experiment, as expected, could correspond to probing of the moon to a depth of 50 km. It was noted that fluctuations of the moon as a result of the fall onto it of the last stage of the rocket lasted 3 h, 20 m, which is due to the intense scattering of seismic waves in the depths of the moon.

The cosmonaut left in circumlunar orbit during the landing of the two crew members on the moon was to photograph the region of the Penzorin crater and several others--proposed landing places for future crews. For this purpose a special camera was built with a focusing distance of 45 cm, a relative aperture of 1:4 and a frame of 11 x 11 cm. The resolution was around 1 m from an altitude of 15 km and 4.5-7.5 m from an altitude of 11 km. A compensation was planned for displacement of the image with exposures of 1/50, 1/100 and 1/200 sec. The film was Kodak SO 349. The dimensions of the camera were 26.7 x 31.1 x 71.4 cm. The weight was 26 kg.

The start took place at 19 h, 13 m world time on April 11 (with a delay of 0.6 sec from the calculated moment). But numerous failures began to plague "Apollo-13" even before the start and as a result not one of the flight assignments was fulfilled.

A week before the start it was discovered that the backup for F. Hesse, Charles Duke, was ill with erysipelas and had had contact with all the members of the chief and the backup crew. Tests for immunity to this illness showed that the pilot of the command module, Thomas Mattingly, who was designated for the basic crew, did not have such immunity and could become ill in flight. Therefore he was replaced by J. Schweikert. Lovell proposed that the flight be postponed to May, but this would have entailed additional expenditures (of about $0.8 million) and they did not agree with him. Twenty-four hours before the start, at 19 h, on April 10 a decision was adopted to launch the spaceship with a new crew (Lovell, Schweikert and Hesse).

Twenty-four hours before the prestart check, an increase in the temperature of the balloon with helium of the landing stage was discovered. The disorder was eliminated.

After the start, the central engine of the second stage for unknown reasons arbitrarily switched off two minutes earlier than the calculated time, and Lovell had to prolong the work of the engines of the third stage by 34 sec. The object weighing 134.5 t was launched into geocentric orbit, but the perigee of the orbit was 188 km and the apogee was 226 km (the calculated circular orbit had an altitude of 190 km).

Four h, 35 m after the start a 7-minute television broadcast was made, but the quality of the image was so poor that it was not transmitted to the commercial network. At 21 h, 48 m, a second switching on of the engines of the third stage occurred, and the ship transferred to a flight trajectory toward the moon which was close to the calculated one. But one of the engines worked several seconds less than the calculated time, and during the last minutes of their work a noticeable vibration was perceived.

At 22 h, 19 m, at a distance of about 8,000 km from the earth, a reconstruction of the sections of the ship began. Schweikert performed the operation and dealt with the assignment excellently. He successfully ensured the navigation of the spaceship also. After separation, the last stage was directed toward the moon. In order to ensure its fall into the prescribed region of the moon, correction was made with the aid of auxiliary engines. The reconstruction of the sections was shown on television. /42

On April 12 at 7 h the cosmonauts began their rest. They slept 5.5 h apiece, after which they began to have breakfast, consisting of the cosmonauts' favorite dishes. Lovell ate sausages with spicy sauce and noted that in previous flights he did not imagine that he would ever be able to obtain this dish on a spaceship.

On April 13 at 01 h, 43 m (3.5 hours earlier than the planned time) the first transfer to the lunar module began. From there the first television broadcast was made.

At 3 h, 08 m, soon after return from the lunar module, the cosmonauts heard a strong rumble, like an explosion, and sensed a vibration, after which the voltage of the current produced by the fuel elements of the main module began to fall sharply. Two out of three batteries went out of commission and they switched them off. Then began troubles in the third (last) battery. The transition was made to minimal energy consumption. The instruments showed a slack of pressure in one of the oxygen tanks and a slow drop in pressure in the other. Through the window it was possible to see the flow of some kind of gas from the tanks of the main section into a vacuum; numerous shining particles appeared, and after some time the windows were covered with freezing water vapor. At 4 h, 49 minutes, the Space Center informed the cosmonauts that the battery of the fuel elements would be able to produce energy for only 15 m longer. Lovell and Hesse transferred to the lunar module, switching on 6 chemical batteries and a life-support system there. From there the oxygen went into the crew section where Schweikert remained, using only a hand lantern for illumination to save electrical energy. The flow of oxygen out of the tanks that had been damaged by explosion led to destabilization of the ship and made communications difficult, inasmuch as the antennas lost the earth. But in this emergency situation the cosmonauts kept calm and composed. Their pulse directly before the explosion, 1 min and 1.5 min later was, correspondingly: 66.105 and 120 for Lovell, 69.88 and 104 for Hesse, and 30.95 and 115 for Schweikert.

At 6.00 h the flight leadership announced a prohibition of the landing on the moon and emergency return to earth after flying around the moon. There remained practically no supplies of water, electrical energy, and oxygen in the engine section, but a large amount of oxygen in the lunar section which, with an economical expenditure of it, should be sufficient for the return. With the help of the engines of the landing stage of the lunar section, "Apollo-13" was transferred to a trajectory of free return. Orientation was made by the control system of the same section, and in a number of cases, by hand. On April 14 none of the cosmonauts slept.

On April 15 at 0 h, 21 minutes the approach of the ship to the moon began, which lasted 25 m. The ship flew around the moon at a minimal distance of about 250 km. During fly-by the cosmonauts made a number of photographs of the lunar surface. At a distance of about 10,000 km from the moon, with the aid of engines of the lunar section still another correction was made for ensuring landing of the ship in the Pacific Ocean near the islands of Samoa. They avoided using the flight engine because of its possible damage by the explosion. All systems of the ship, except for life-support systems and the telemetry systems, were switched off. Communications with the earth occurred rarely, with the use of a powerful radiotelescope in Parks (Australia). In order to regulate the temperature, the spaceship was periodically turned at a 90° angle relative to the longitudinal axis. Illumination in the lunar section was incomplete; in the main section it was not switched on. The temperature here decreased to 2-5°C; in the lunar section it was somewhat higher.

At 3.00 h the signalling device reported that the allowable level of carbon dioxide had been exceeded. Soon its partial pressure reached 15 mm Hg. The balloons absorbing this gas were replaced with lithium hydroxide. Later, with the help of hoses detached from the pressure suits, having joined them with improvised materials (insulating tape, cardboard from the casing of the flight journal, etc.) the cosmonauts joined the /43 life-support system of the lunar section with one of the 16 cartridges of the crew section and thus ensured regeneration of air in the lunar section, where it was somewhat warmer, and the cosmonauts stayed here, despite the extremely crowded conditions. The spaceship was extremely dirty, the humidity of the air increased, and the sanitation system was out of order. In the lunar section the voltage of the accumulators suddenly decreased, accompanied by noise and an ejection of liquid. On the night of April 16 the safety valve for the tank with liquid helium was broken off. The flow of gas led to the rotation of the ship.

Realizing the dangerous situation for the crew of "Apollo-13," the Soviet government on April 15 gave the instruction to four ships which were in regions of the Pacific Ocean near the spot of probable landing of the crew to change course to go to the landing point and if necessary to give aid. At the same time the ships were given the order to cease radio broadcasting into the air in a range of frequencies used by the spaceship. The government of the USA expressed deep thanks in connection with this, considering this fact an example of international cooperation and practical realization of agreements on the rescue of cosmonauts which went into force in 1968.

The development and procedure for carrying out the operations which the cosmonauts had to make in the last hours of flight took place on training machines and modeling devices on the ground by the most experienced cosmonauts of the USA, and also with the aid of an electronic computer. The recommendations worked out were transmitted on board the spaceship.

On April 17 the cosmonauts could rest till 11 h, and, for the first time after the emergency, simultaneously. But even in the lunar section it was so cold that they slept significantly less, and after waking up they were obliged many times to take two tablets of stimulants apiece, and they began preparation for descent. At 12 h, 53 m, with the aid of engines of the orientation system of the lunar section, the last correction of trajectory was made, and at 13 h, 16 m, the separation of the engine section. The cosmonauts were able to examine it and photograph it. It turned out that throughout its entire length a large part of the body was torn out by explosion, the nozzle of the flight engine was damaged, and large fragments hung on tangled tubes and pipes. "Complete chaos," they reported to the Center.

At 16 h, 27 m, Lovell was the last of the cosmonauts to transfer to the command unit and in 16 m, at a distance of 21,000 km from the earth, the lunar section, which served the cosmonauts as a "rescue boat," was separated. It was noted that if the explosion had occurred on the return flight from the moon, when this unit was gone, the cosmonauts would have unavoidably perished. Despite the psychologically stressful moment, the pulse of all the cosmonauts was around 100.

At 17 h, 54 m, the unit of the crew entered the atmosphere (speed of entry around 11 km/sec, the highest for the "Apollo" spaceships), and at 18 h, 08 m they landed near the islands of Samoa at a point with coordinates of 12°40 south latitude, 165°83' west longitude. At 18 h, 53 m the cosmonauts were taken onto the helicopter carrier "Iwo Jima," after which for several hours they rested on the islands of Samoa. Their condition was satisfactory, but Hesse was discovered to have a slight cold and his temperature rose to 38.2°.

To investigate the reasons for the accident, a commission was appointed, into whose efforts about 300 scientists and engineers were drawn. In the course of the investigation, about 100 tests were made on flight systems. The expenditures on this work were $1 million. It was established that in the engine section the tank with liquid oxygen exploded as a result of the failure of the safety devices in the system of the electrical heater, which might not have occurred with the proper prestart control. These devices went out of order due to violations by the firm which supplied the conditions for the technical assignment, according to which the the devices were to have been rated at more than double the voltage. With a full tank they worked satisfactorily, but with a lowering of the oxygen level overheating occurred, a break in the insulation of the pipes, and short circuit and explosion followed. And the second oxygen tank was damaged by fragments. In conclusion, the commission pointed out that "the accident is not a result of a chance mistake in the statistical sense, but rather the result of an unfavorable combination of mistakes and an unforgiveable deficiency in design."

The cost of the flight of "Apollo-13" was $375 million. /44

VII. Military Satellites

1. "Vela" Satellites ("NDS")

"Vela-11" and "Vela-12" (No. 905, April 8, 1970). The construction was similar to that of previous satellites of this series (cf. No. 814). In each of the corners of the 26-sided body of each satellite were placed 28 instruments, registering nuclear explosions, solar flares, and solar wind. The weight of satellites was 245 kg apiece.

In contrast to previous launches of satellites of this series, when as additional load 1-3 small satellites were simulteneously put into orbit, this time there were no additional satellites.

2. Spy Satellites

A significant number of the satellites launched by the USA in 1970 belonged to the Deparment of Defense and did not receive a name. The purposes of the launch of these satellites were also not reported. Ten such satellites were launched in 1970 (in 1969, 16).

In recent years in the USA, as was reported in the public American press, a satellite system of antimissile defense was created. This system after completion will consist of six satellites in synchronous orbits (two over the western part of the Indian Ocean, two over Singapore, one over the central part of the Atlantic Ocean, and one over the central part of the Pacific Ocean). The system is designed for discovery and tracking of ballistic rockets of a potential opponent in the initial section of their trajectory and is being developed according to "program 647" (previously "program 949"). The code number "647" was also given to satellites going into orbit that register the illumination of the flare of rocket engines in the near infrared part of the spectrum. Besides, onboard the "647" satellites there is apparatus for discovery of atomic explosions in the atmosphere and a television camera with a telescopic lens. The satellites are stabilized in rotation and are powered by solar batteries.

After discovering the emission of gases by rocket engines, the satellites in several seconds report information on this to a ground station in Alice Springs, Australia (this applies to satellites that are in orbits in the eastern hemisphere), which transmits the data to a computer center in Sunnyvale, California. For reception and transmission of information there is also a station on the island of Guam (Mariana Islands, eastern latitude of about 145°), connected with the center in California by underwater cable.

For reception of information from "647" satellites which are located in the western hemisphere, a synchronous satellite-transmitter ("program 313") is being developed, working in a range of millimeter waves, ensuring secrecy of communications and equipped with a pencil-beam antenna.

In 1968 and 1969 one each of the "647" satellies (Nos. 712 and 804) were launched into orbits close to synchronous. Apparently, they were experimental. In 1970 three such satellites were launched:

Satellite "1970 46A" (No. 924--June 19, 1970)--went into synchronous orbit. The last stage of the rocket remained in intermediate orbit, which testifies to the presence onboard the satellites of a sufficiently powerful apogee engine that ensures transition to a circular, nearly stationary orbit and a change in inclination toward the equator.

Satellite "1970 69A" (No. 947--September 1, 1970)--went into synchronous orbit over Singapore. Apparently a cylinder with a diameter of 1.4 m, length of 1.7 m, weight with fuel of the apogee engine of around 700 kg.

Satellite "1970 93A" (No. 971--November 6, 1970)--launched into approximately synchronous orbit over the Indian Ocean. A cylinder with a diameter of about 3 m, length about 7 m, weight about 800 kg.

It was reported that military satellites are being developed /45
also for discovery and tracking of ballistic missiles launched from submarines ("program 749"), equipped with radar equipment, which ensures the discovery of ballistic missiles in low orbits. There is no information about the launch of such satellites or about the designation of the other spy satellites.

C. ARTIFICIAL SATELLITES OF OTHER COUNTRIES

1. The English Artificial Satellite "Orba"

In executing the national space program, English scientists in 1962-67 launched jointly with the USA three "Ariel" or "UK" satellites (Nos. 93, 220, and 564), took active part in supplying satellites with "OSO-5" (No. 774) and "OSO-6" (No. 836) scientific apparatus, and also in the building of rockets and satellites according to the ESRO program (cf. No. 733). At the same time in England a three-stage "Black Arrow" rocket was being developed, successful experimental launches of which (R0 and R1 modifications) were made in June 1969 and in March 1970.

On September 1, 1970 the third "Black Arrow" rocket (R2) was launched from the Australian proving ground of Boomer. The purpose of the launch was to put into polar orbit with an altitude at perigee of 350 km the spherical satellite "Orba"--the first English satellite, with a diameter of 75 cm and weight of 82 kg. Its purpose was the study of the upper layers of the atmosphere. On the satellite a UKV (decimeter) range transponder was installed.

But the engine of the second stage worked 13 sec less than the calculated time (135 sec) and the rocket could not impart to the satellite the necessary speed.

The building of the "Black Arrow" rocket took about 5 years, and 3 million pounds sterling were spent on it annually. The English specialists do not consider it necessary to make changes in its design, and plan with the aid of its last modification (the R2) to put several satellites into orbit in 1971-1972.

2. The English Satellite "Skynet-2"

In 1969, after the launching of the Skynet-1 satellite (No. 869), the English military system of satellite communications, "Skynet," began operation. This satellite, located over the Indian Ocean (50° ± 6° east longitude) ensures reliable telephone-telegraph communications with ground stations and several large military ships. It is planned to install on a large number of ships "SCOT" terminal stations (Small Communication Terminal), which will ensure teletype communications. These stations are supplied with parabolic antennas with a diameter of 3.5 m.

In the English military satellite communications system it was planned to have two satellites alike, one of which was a "Skynet-1," and the other, similar in design, was to be located in stationary orbit over the Indian Ocean also and to be a reserve in case the first satellite was to go out of commission.

In the future, in the second stage of the creation of the system, more improved "Skynet" satellites were to be used, developed and produced in the U.S.A. on orders from the Ministry of Defense of England under common supervision and with the technical aid of the U.S.A. The launching of the new "Skynet" satellites is planned to begin in 1973.

"Skynet-2" (No. 940--August 19)--the second satellite of the English military satellite communications system, built in the USA and exactly like the satellite "Skynet-1" (No. 869). The starting weight was 243 kg, and the weight after entry into stationary orbit, 129 kg.

The satellite went into transfer orbit and in the calculated time the apogee engine was switched on to transfer it into stationary orbit. But this engine worked 14.5 sec instead of 27 sec, after which the signals of the satellite were lost and its further fate was unknown.

In connection with the unsuccessful launch of the "Skynet-2" satellite, the launching of the second satellite of the NATO communications system, planned for September 30, 1970, was also postponed.

3. The French Satellite "PEOLE"

"PEOLE" (No. 987--December 12, 1970)--an experimental launching in the Aeolus program (named for the God of the winds in ancient Greek mythology). The program includes the launching of a special satellite and 511 balloon-probes from the territory of Argentina to an altitude of about 12 km between 20 and 70 parallels south latitude. The satellite, in orbit at an altitude of about 900 km with an inclination of about 50°, examines the balloons located at the given moment in its visibility zone. Information on pressure and temperature taken from the balloons is noted down onboard the satellite (the memory apparatus is calculated to store data on 1,000 examinations) and is transmitted to ground stations that transfer data to the Center (Brittany, France). Furthermore, according to the Doppler displacement of frequencies of the transmitters of the probes, the distances to them are determined and, according to several such measurements, the current coordinates of the balloon, which permits the determination of the wind speed also (cf. also p. 56). /46

The satellite "PEOLE" (Préparatoire à "Eole"--preparation for launch in the "Aeolus" program) is used for geodetic measurements. For this purpose there are 44 angular reflectors of laser beams on its surface. This part of the measurements is connected with the international program for geodetic observations with the help of satellites (ISAGEX--International Satellite Geodetic Experiment), for which the two French "Diadem" satellites are observed (Nos. 533 and 536), several American satellites and the ESRO satellites. Sixteen countries are taking part in its implementation. The geodetic measurements with the aid of the "PEOLE" satellites are made chiefly in the region of the Equator.

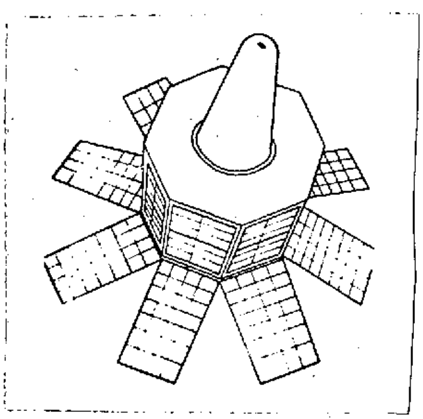

Fig. 13

The satellite (Fig. 13) is an 8-sided prism 0.55 m high and with a described diameter of 0.704 m, with 8 solar panels and an antenna in the form of a truncated cone for communications with the balloon probes. The weight of the satellite is about 70 kg. The antenna is oriented to the earth. The satellite is stabilized for four days after going into orbit by a system of gravitational stabilization, consisting of a pivot moving out of the body (beryllium ribbon on a roll), with a load of 3 kg on the end. The period of active existence is 2-3 months.

"PEOLE" went out into orbit somewhat lower than calculated, but this had little effect on the results of the experiments.

As was noted in the French press, the "Aeolus" program is an example of how at relatively little expense very interesting problems may be raised and solved with the use of space technology.

4. The Japanese Satellite "Osumi"

The beginning of space studies in Japan dates to 1954 when work began on the building of rockets by a group of scientists at Tokyo University, supported by a number of firms and the government, which was striving for the participation of Japan in the International Geophysical Year (IGY).

The first rocket in Japan was the solid-fuel rocket "Pencil," with a diameter of 17 mm and a length of 230 mm; the second, in 1956, was "Baby," with a length of 1,000 mm. On the basis of these rockets the development of a series of small solid-fuel "Kappa" rockets began (in the future Japanese rockets will be designated by Greek letters, indicating the series, with the addition of Arabic numbers and Latin letters, designating the model). In 1958, according to the program of the IGY, "Kappa-6" was launched at an altitude of 60 km. Its models "8L" and "8M" could lift respectively, loads of 25 kg to altitudes of 180 km and 360-400 km. Simultaneously with the improvement of "Kappa," the "Lambda" rocket was developed. The first of them, "Lambda-2," 16.5 m long and weighting 6.5 t, lifted a payload of about 200 kg to an altitude of about 200 km.

"Lambda-4S" was designed for launch of an experimental /47
satellite. It is a four-stage, solid-fuel rocket 16.5 m long with a maximum diameter of 0.73 m and a weight of about 9 t. The thrust of all the engines is about 64 t. Its spherical fourth stage carries an inseparable satellite. Launches of this rocket with the satellite were undertaken on September 26 and December 20, 1966, and also on January 13, 1967 and September 22, 1969. But all of them were unsuccessful. The fifth launch took place on February 11, 1970. The "Osumi" satellite (see below) went into orbit. The new launch on September 25, 1970 again ended in failure.

At the same time in Japan a more powerful solid-fuel "Mu" rocket and its modifications are being developed, designed for launching into orbit a series of research satellites weighing about 75 kg. The fourth (last) stage of this rocket works on products of the decomposition of hydrogen peroxide, the remaining stages on solid fuel, as do all Japanese rockets. This is due to specific conditions: due to the great density of population in Japan, it is difficult to find a sufficiently large area, free of residential buildings, such as is necessary for the launching of rockets using liquid fuel. Besides, the solid fuel is reliable and safe in usage.

The development of new four-stage rockets is being carried out. The rocket "Q" (altitude, 25.2 m; diameter, 1.39 m; starting weight, 40.6 t; thrust, 11 t) in 1972 was to launch a research satellite weighing 85 kg into orbit with an altitude of about 1,000 km. On its basis the rocket "N" will be built (altitude, 28.6 m; diameter, 2.32 m; starting weight, 108.5 t). By means of it in 1973-74 it is planned to launch an experimental communications satellite weighing about 120 kg into synchronous orbit, and then several navigational satellites. The third stages of these rockets work on liquid fuel, the rest on solid fuel.

Up to 1974 Tokyo University plans to put 10-13 satellites into orbit. The national center for space research plans 12 more satellites. Up to 1978, the launching of 62 satellites in Japan is planned.

The expenditures by Japan on space research are increasing swiftly. From 1955 through 1970 $95 million was spent; in the 1970-71 fiscal year (from April 1, 1970) $68.6 million will be spent; and for 1974-77 $741 million is planned.

For launching of the rockets "Lambda-4" and "Mu-4" a space center was built in Kahosima (Kyushu Island). In 1967, on the request of the crews of fishing vessels, the launches of rockets from this testing ground were forbidden and were made from the Utinoura testing ground. A launching pad is being built on the island of Tanegasima (a group of small islands of Osumi, south of the island of Kasyu).

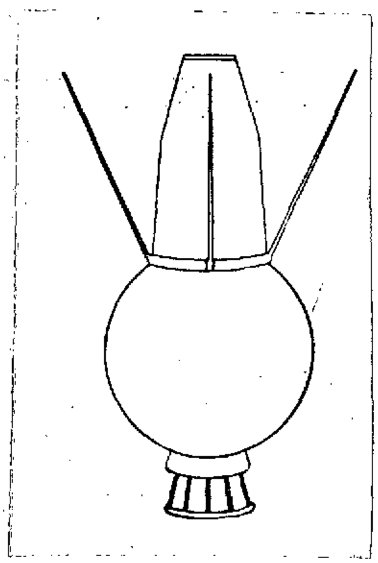

Fig. 14

"Osumi" (No. 889--February 11, 1970). The satellite received its name from the name of the island on which the Utinoura testing ground is located. The satellite was a container in the form of a truncated cone 0.97 m high, with a diameter at the base of 0.48 m and a weight of 22.5 kg, installed on the spherical fourth stage of the rocket (Fig. 14). Inside the container was a thermometer, an accelerometer, and a radio beacon at a frequency of 131.6 mHz, working from chemical sources of current, calculated to last 30 h. The total weight of the equipment is 9.4 kg.

The speed of combustion of the fuel of the fourth stage turned out to be lower than calculated; therefore the equipment in the container heated up to a temperature of +100°C and communications with the satellite ceased 11 h after it went into orbit.

The cost of the satellite was $388,000; the cost of the rocket with development and tests was $333,000,000.

5. Chinese Artificial Earth Satellite

The creation of ballistic missiles in China began in 1956, after the return from the USA (where he was from 1935 through 1955) of the Chinese scientist Tsian Siu-Shen, Colonel of the Armed Forces of the USA, head of the Department of Rocket Engines at the California Institute of Technology, and a military expert. West German specialists also participated in the realization of the Chinese space program. According to data from the USA, obtained with the aid of reconnaissance satellites, the construction of launching pads in China has been taking place since 1956. As the Indian press reported, in recent years about $6 billion has been spent annually on the building of the Chinese satellite. /48

"China-1" ("Red East-1," "Chincom-1," No. 912--April 24, 1970--names of the first Chinese satellite adopted in the Western press). According to observation data of the King Military-Air Research Center (D. King Healey, England)--a sphere with a diameter of about 1 m, weight of about 173 kg. The transmitter, on a frequency of 20,009, adopted for space objects (although the Chinese People's Republic is not a member of the International Council of Electrical Communications), worked in cycles of one minute apiece. Of this time, for 40 sec the melody of the song "The East is Red" was transmitted, then followed a 5-sec interval, a 10-sec telemetry (apparently information on the temperature inside the satellite), and a new 5-sec interval.

The military experts of the USA suggest that reconnaissance apparatus is also included among the useful payload (this explains, in their opinion, the choice of inclination of the orbit toward the equator, at which the satellite flies over the territory of the USA and the USSR) and that possibly the calculated orbit should be circular. According to the same data, the launch was made by a "Titan-2" solid-fuel rocket with an additional stage, also launched into orbit. Such a rocket can launch into circumterrestrial orbit with a small inclination to the equator a satellite weighing about 400 km and can serve as an intercontinental ballistic missile, capable of delivering a load of 600 kg a distance of about 12,000 km. Western specialists disagree as to the location of the launching pad: according to some data, it is located near the nuclear center at Locnor, according to others, about 10° to the east, in the region of Shuanchentsa (41° north latitude, 100° east longitude).

D. INTERNATIONAL SATELLITES

1. The "Interkosmos" Satellites

In accordance with the program of cooperation of socialist countries in the field of the study and use of outer space for peaceful purposes, in 1970 the satellites "Interkosmos-3" and "Interkosmos-4" were launched in the Soviet Union.

"Interkosmos-3" (No. 935--August 7, 1970). Designed for the study of the radiological situation in circumterrestrial space, study of the connection of dynamic processes in radiation belts of the earth with solar activity, and study of the nature and the spectrum of low-frequency electromagnetic oscillations in the upper ionosphere.

On board the satellite these scientific instruments were installed:

- apparatus for the study of the composition and temporal variations of charged particles (protons, electrons, alpha particles) developed and produced in the Czechoslovak Socialist Republic with the participation of specialists from the Soviet Union (Charles University in Prague, Institute of Experimental Physics of the Slovak Academy of Sciences in Koshidsa; Institute of Space Research of the USSR Academy of Sciences, Moscow State University);

- apparatus for the registration and analysis of the spectrum of low-frequency electromagnetic waves and signals in ranges of frequency of from 0.7 to 12 kHz, and also from 0.5 to 15 kHz, developed and produced jointly by specialists of the Soviet Union and the Czechoslovak Socialist Republic (Institute of Terrestrial Magnetism, the Ionosphere, and Distribution of Radio Waves of the USSR Academy of Sciences; Geophysical Institute of the Czechoslovak Academy of Sciences);

- A three-component magnetometer for measurement of the magnetic field of the earth and determination of the orientation of the satellite, developed and produced in the Soviet Union.

In preparation of the satellite for launch, specialists from the ChSSR took part in the installation and tests of the scientific apparatus.

Simultaneously with measurements on the satellite /49
"Interkosmos-3," the scientific institutions of the People's Republic of Bulgaria, the German Democratic Republic, the Polish

People's Republic, the USSR, and the Czechoslovak Soviet Socialist Republic conducted ground measurements of low-frequency radiation of the outer ionosphere according to the agreed program.

Flight control was handled by an operative groups of specialists from the USSR and the ChSSR. And the scientific information from the satellite was received by ground stations in the GDR, the USSR, and the ChSSR.

By October 1, 1970, the "Interkosmos-3" satellite had made 807 revolutions around the earth. All systems were working normally. The most intensive work of the scientific apparatus was done in the period of August 7-13, August 19-26, and September 10-19 in connection with geomagnetic disturbances caused by a significant increase in solar activity.

"Interkosmos-4" (No. 962--October 14, 1970). Designed for continuation of joint studies of the ultraviolet and X-ray radiation of the sun and the influence of this radiation on the structure of the upper atmosphere of the earth-studies began on the satellite "Interkosmos-1" (No. 856). Onboard the satellite was installed scientific apparatus developed and produced by specialists from the GDR, the USSR, and the ChSSR. The design of the satellite was basically similar to the design of "Intercosmos-1."

In preparation of the satellite for launch, specialists of the countries indicated took part in setting up and testing the scientific apparatus. The flight control of the satellite was handled by an operative group of specialists of the GDR, the USSR, and the ChSSR. Simultaneously with the measurements on the "Interkosmos-4" satellite observatories of the People's Republic of Bulgaria, the Hungarian People's Republic, the Polish People's Republic, and GDR, the SRR, the USSR, and the ChSSR made radio-astronomical, ionospheric, and optical observations according to the program agreed upon.

By December 9, during 56 hours of flight, the "Interkosmos-4" satellite made 870 revolutions aroung the earth. The condition of its systems was normal.

2. The Satellite of the ESRO Organization

In 1970 the cost of the European space program carried out by ELDO-ESRO (cf. "Bulletin of stations of optical observations of artificial earth satellites" No. 59, 1971) was about $140 million, of which about 40% was used for development and building of satellites and about 60% for the building and launching of rocket carriers. It is planned that in 1971 this sum will increase to $160 million, and in 1973-74 it will reach $260-$270 million (in connection with the development during these years of the "Europa-3" rocket) and by 1980 it will reach a level of $180-$220 million. In 1970 it was decided to limit the use in Europe of rocket carriers of foreign origin and to make new tests of the "Europa-1" rockets.

On June 12, 1970 the regular launch of this rocket was made from the Boomer Firing ground (Australia). It was planned to launch into orbit with an altitude of perigee of 400 km and an altitude of apogee of 2,000 km an experimental satellite (weight, 214 kg) with apparatus designed for study in the field of distant radio communications and for radio control of the orbit. After the start, the first stage (English) and the second (French) worked normally, but in the work of the engine of the third stage, produced in the FRG, disorders were observed. In the 78th sec of flight, troubles arose in the electrical circuit, as a result of which the fairing did not separate. The apparatus did not go out into orbit.

In accordance with the program, the launching of the "Europa-1" F-9 rocket was the last, since the launch of the F-10 was postponed due to financial difficulties. It is possible, however, that it will be made, after which it is planned to begin launches in the "Europa-2" program, designed for launching into orbit the French-West German communications satellite "Symphony."

3. The French-West German Satellite "DIAL"

France and the FRG, in conducting their national space programs, are taking active part in the work of ESRO and at the same time are working on a joint program. The contribution of France to space research was $75.8 million in 1969, and in 1970, $65.3 million; the contribution of the FRG was correspondingly /50 $60.2 and $50.7 million.

In 1970, with the aid of the French rocket "Diamant-B," the satellite "DIAL," produced in the FRG by the firms of Junkers and Messerschmidt, was launched from a proving ground in French Guiana At the same time, the first test was conducted of the modified "Diamant-B" rocket with an increased thrust (35 t instead of the 28-t "Diamant-A", with the help of which the French satellites were launched into orbit) "Diamant-B" permits the launching into a circular orbit with an altitude of 500 km of a satellite weighing up to 120 kg, while the previous rocket could put into the same orbit a satellite of only up to 40 kg. The agreement between France and the FRG on joint development and launching of the "DIAL" satellites was concluded on February 18, 1969.

"DIAL" (No. 895--March 10, 1970). The name of the satellite comes from the abbreviation for the words "Diamant-Allemand"--the German satellite on the "Diamant" rocket. An eight-sided prism with a height of 101 cm (with an instrument container of 2.06 m) and with a described diameter of 0.63 m. The total weight was 120 kg, weight of the payload was 63 kg (Fig. 15).

The satellite consisted of two capsules: the lower--"MIKA" (minicapsule)--weighing 52 kg, inseparable from the last stage and designed for collection and transmission of information on the launch from the moment of launch and until emergence into orbit at an altitude of about 350 km, in particular for measurements of accelerations, flight trajectory, determination of spatial position, speed of rotation of the third stage, level of vibration, conditions of separation of the fairing. The capsule was equipped with a telemetric system, a radio transponder, and a radio beacon. The calculated time of its work was 1 h (B in Fig. 15).

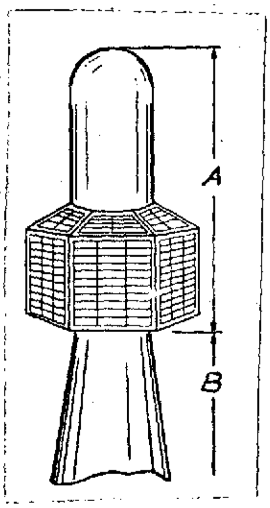

Fig. 15

The capsule "WIKA" (Wissenschaftliche Kapsel), weighing 61 kg (A on Fig. 15) was designed for studies of the geocorona, measurements of the intensity of radiation in the range of Lyman-alpha, the density of electrons, intensity of streams of high-energy particles, study of the interaction of ions with the magnetic field of the earth, and studies of the geomagnetic pole. With the help of a magnetometer the relative position of the satellite was determined. A photometer for measurement of the intensity of Lyman-alpha radiation had three sensors located at angles of 30°, 90°, and 150° to the axis of rotation of the satellites. The program of measurements consisted of two cycles: on the illuminated side for 66 m, and on the non-illuminated side for 39 m. The accumulators and solar batteries were designed to last 25-30 days. In order to save electrical energy, in two out of three revolutions of the satellite around the earth, a relay interrupted the power supply circuit. The telemetric transmission was made by a device similar to the one installed on the satellite "Azure" (No. 865), with a rate of 1,920 bytes/sec. The recording of information on board was not planned, and therefore it could be received only in real time by stations located in low latitudes and in a range of longitudes from 45° east to 85° west. It was stabilized in rotation (180 rpm).

The vibration of the first stage in the first 15-18 sec of flight with a frequency of 40 Hz led to the failure of the "MIKA" capsule at the very beginning of the flight, and it fell into the ocean from an altitude of 40 km at a distance of 620 km from the launch site.

The cost of the satellite was 11 million West German marks.

4. American-Australian "Oscar" Satellites

The "Oscar" satellites (Orbiting Satellite-Carrying Amateur Radio) are being developed with the purpose of making experiments on the distribution of ultra-short radio waves, the study of the possibility of receiving signals from onboard space machines by /51 amateur radio methods, and also for communications with amateur radio operators of various countries through the satellite as a retransmitter. They were launched in 1961, 1962, and (two satellites) in 1965 (see Nos. 77, 100, 308, and 400). In 1970 two "Oscar" satellites developed by Melbourne University (Australia) were launched.

"Oscar-5" (No. 886--January 23, 1970). In design similar to the satellite "Oscar-3" (No. 308). A square box measuring 0.6 x 0.4 x 0.2 m. Weight, 18 kg; weight of batteries, 9 kg. One transmitter with a power of 250 mV worked on a frequency of 29.44 mHz (wave length, about 10 m), the second, with a power of 50 mV, at a frequency of 144.05 mHz (wave length about 2 m). The first transmitter, requiring the output of a large amount of electrical energy, was switched on only on Saturdays and Sundays; the second worked constantly. Under such conditions of work the calculated time limit of work of the radio apparatus was two months.

It was launched into orbit together with the satellite "ITOS-1" (cf. p. 52).

"Oscar-19" (No. 945--August 27, 1970)--repeat of the previous launch. First launched into orbit as an independent payload of the "Scout" rocket.

5. NATO Communications Satellites

The country participants of the Organization of the North Atlantic Treaty (NATO--North Atlantic Treaty Organization), created in 1949, plan to build a satellite communications system in three stages.

The first stage (1966-1968) plans the study of the possibility of such a system. In this stage experiments were made in communications with the use of military satellites of the USA "IDCSP," launched into synchronous orbits by a series of 4-8 satellites apiece (cf. Nos. 457, 525, 588, 699). In the experiments, stations in the USA and two mobile ground stations in Belgium and Italy, equipped with parabolic antennas with a diameter of 4.8 m, took part.

The second stage plans the launching into stationary orbits of two "NATO" satellites, the creation of 12 stationary ground stations (the last of them is to be put into operation no later than June, 1971) with parabolic antennas with a diameter of 12 m and several ship-based stations (on flagships) with antennas with a diameter of 6 m. The stationary stations will be located in the USA (Washington), Canada (Ottawa), England (London), Belgium, Denmark, the Netherlands, Greece, Italy, Norway, Portugal, Turkey, and the FRG. Iceland and Luxemburg, which are participants in NATO, will not have stations for satellite communications. The fifteenth country belonging to NATO--France--adopted a resolution not to participate in the creation of the system of satellite communications of this organization. The second stage and the beginning of operation of all the stations is planned for completion in June, 1971.

The guidance and control center for communications satellites was built near the headquarters of NATO in Brussels. Expenses on this stage are $50 million, including a cost of $10 million for each satellite.

In the third stage a satellite system will be created which will ensure communications of the command with tactical subdivisions through mobile ground stations with an antenna with a diameter of 1.8 m. For this it is planned to develop a special satellite or to modify one of the existing ones (the "NATO-1" of "Intelsat-3").

"<u>NATO-1</u>" (No. 899--March 20, 1970). A cylinder 0.81 m long (with an antenna of 1.6 m) and a diameter of 1.37 m. The starting weight was 243 kg, after emergence into stationary orbit, 117 kg. On the lateral surface are 7,000 solar elements (Fig. 16). In the upper part is an antenna with a mechanical antirevolving

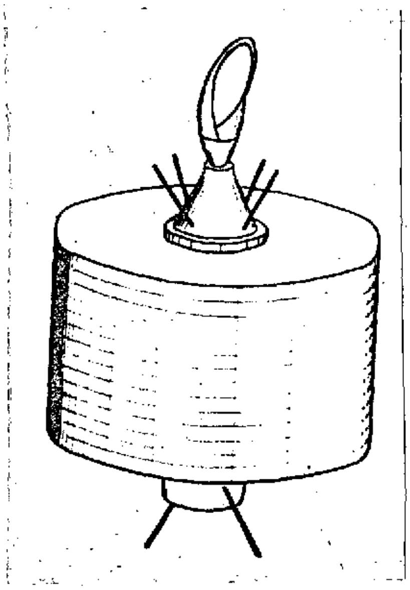

Fig. 16

device (the satellite is stabilized in rotation); in the lower part, an apogee engine with a thrust of about 2 t.

The purpose of the satellite was to ensure a direct line of communications between the NATO staff in Brussels and other country participants in this organization and the armed forces of NATO in the northern hemisphere of the earth from the eastern part of the USA to Turkey.

The satellite was launched into intermediate orbit at an altitude at perigee of 28 km and an altitude of apogee of 37,048 km and in the sixth orbit it was transferred to stationary orbit over the Atlantic Ocean (18° west longitude).

After the experimental operation of the satellite, insufficient power in the energy system was noted. Furthermore, the communications system was hardly used, inasmuch as not all the ground stations had been built.

On September 30, 1960 it was planned to launch a second satellite of the NATO communications system, but, in connection with the unsuccessful launch of the "Skynet-2" satellite (see above), the "NATO-2" satellite was not launched.

APPENDIX

ARTIFICIAL EARTH SATELLITES LAUNCHED UP TO JANUARY 1, 1970, WHICH CEASED TO EXIST FROM JANUARY 1 TO DECEMBER 31, 1970

No.	Country	Designation adopted	Name of object	Period of existence (days)	Date of cessation of existence
3	USA	1958 Alpha	Explorer-1	4,441.29	3/70 31.45
44	USA	1961 Alpha 2	component	3,537.37	10/70 9.22
84	USA	1962 Zeta 2	rocket	2,978.60	5/70 3.27
845	USSR	1955 53 A	Cosmos-71	1,852	8/70 11
443	USA	1966 39 B	capsule	1,627.01	10/70 27.78
478	USA	1966 74 B	capsule	1,296.25	3/70 5.02
501	USA	1966 97 B	rocket	1,188.21	1/70 28.71
542	USA	1967 20 B	rocket	1,137.71	4/70 19.39
564	USA-England	1967 42 A	Ariel-3	1,309.98	12/70 5.65
594	USA	1967 72 B	rocket	1,207	11/70 15
653	USA	1968 04 A	spy satellite	902.32	7/70 7.34
657	USA	1968 08 B	capsule	769.76	3/70 4.69
669	USA	1968 20 B	capsule	659.85	1/70 3.77
690	USA-Europe	1968 41 B	rocket	682.83	3/70 30.92
701	USA	1968 52 B	capsule	569.24	1/70 11.15
733	USA-Europe	1968 84 A	Aurora	630.41	6/70 26.28
788	USSR	1969 20 A	Cosmos-268	430	5/70 9
793	USA	1969 25 A	OV-1-17	352.23	3/70 5.55
799	USSR	1969 31 A	Cosmos-275	316	2/70 7
824	USA	1969 56 A	Bios-3 adapter	205.43	1/70 20.57
858	USSR	1969 90 A	Cosmos-303	97	1/70 23
862	USSR	1969 94 A	Cosmos-307	432	12/70 30
862	USSR	1969 94 B	rocket	269	7/70 20
864	USSR	1969 96 A	Cosmos-308	61	1/70 5

No.	Country	Designation adopted	Name of object	Period of existence (days)	Date of cessation of existence
870	USSR	1969 102 B	rocket	56	1/70 19
874	USSR	1969 106 A	Cosmos-314	101	3/70 22
874	USSR	1969 106 B	rocket	47	1/70 27
876	USSR	1969 108 A	Cosmos-316	248	8/70 28
878	USSR-Socialist countries	1969 110 A	Interkosmos-2	164	6/70 7
878	USSR-Socialist countries	1969 110 B	rocket	43	4/70 11